Draft Total Maximum Daily Load for Mercury in the Waters of Jordan Creek, Idaho

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Abbreviations, Acronyms, and Symbols

µ	micro, one-one thousandth
µg/l	microgram per liter
AU	assessment unit
BLM	United States Bureau of Land Management
BMP	best management practice
BoR	United States Bureau of Reclamation
BW	body weight
ºC	degrees Celsius
CCC	Criterion Continuous Concentration
CFR	Code of Federal Regulations (refers to citations in the federal administrative rules)
CERCLA	Comprehensive Environmental Response, Compensations and Liability Act
cfs	cubic feet per second
CMC	Criterion Maximum Concentration
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
ºF	degrees Fahrenheit
FDA	Food and Drug Administration
Hg	Mercury
HUC	Hydrologic Unit Code
IDAPA	Idaho Administrative Procedures Act (refers to citations of Idaho administrative rules)
IDEQ	Idaho Department of Environmental Quality
IDHW	Idaho Department of Health and Welfare
IDL	Idaho Department of Lands
IDWR	Idaho Department of Water Resources
KDMC	Kinross Delamar Mining Company
LA	load allocation
LC	load capacity
MAO	Mutual Agreement and Order
MDEP	Massachusetts Department of Environmental Protection
mg/kg	milligrams per kilogram
MOS	margin of safety
ng/l	nanogram per liter
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NSMP	Nonpoint Source Management Plan
PEL	Probable Effects Level (screening value for sediment that represents the concentration above which toxic effects are likely to occur
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
REMSAD	Regional Modeling System for Aerosols and Deposition
RfD	reference dose
RSC	relative source contribution
SEL	Severe Effect Level (screening value for freshwater sediment represents concentration above which significant adverse impacts on benthic resources are anticipated)

START   Superfund Technical Assessment and Response Team
TEL   Threshold Effects Level (screening value for sediment that represents the concentration
            below which toxic effects rarely occurred)
TMDL   total maximum daily load
TL   trophic level
TRC   tissue residue criterion
USGS   United States Geological Survey
WAG   Watershed Advisory Group
WLA   wasteload allocation

Executive Summary

Jordan Creek, a tributary to the Owyhee River in southwest Idaho and southeast Oregon, does not meet Idaho's water quality standards for mercury. This document is the U.S. Environmental Protection Agency's (EPA's) total maximum daily load to improve water quality in Jordan Creek to ensure that this stream is healthy for humans, fish and wildlife.

The Federal Clean Water Act requires states to identify water quality impaired water bodies and develop total maximum daily loads for those waters. Idaho DEQ included Jordan Creek on its 303(d) list for impaired waters. Jordan Creek is impaired because of mercury pollution. For impaired waters, states develop pollution control plans known as Total Maximum Daily Loads, or TMDLs. TMDLs identify loading caps for pollutants causing the water body's impairment. EPA reviews a state's TMDLs and approves those meeting Clean Water Act requirements, and disapproves those that are insufficiently protective. When EPA disapproves a TMDL for a pollutant, it must issue a replacement TMDL for that pollutant.

A TMDL relies on scientific analysis to calculate the amount and determine the source of a pollutant entering a water body. A TMDL establishes the maximum amount of a pollutant that can be present in a water body while still meeting the state's water quality standard for that water body. Once the maximum pollutant load is established for a water body, the TMDL then apportions specific loading amounts to the contributing sources.

IDEQ issued three TMDLs for impaired waters in the Jordan Creek Watershed in June 2010. The allocations in the Idaho TMDL did not achieve the criterion for protection of aquatic life under conditions of chronic exposure (0.012 ug/l) that is part of the Idaho water quality standards under the Clean Water Act. In 2005 Idaho removed both the acute and chronic water column aquatic life criteria from their water quality standards under the assumption that the fish tissue mercury criteria would be sufficiently protective of aquatic life (IDEQ, 2005). But EPA disapproved the removal of the aquatic life criteria, finding that there was insufficient evidence that the fish tissue criteria for protection of human health would protect aquatic species (USEPA, 2008). EPA believes, under the Alaska Rule (USEPA, 2000) that the 1997 Idaho aquatic life criteria are still applicable.

EPA is issuing a mercury TMDL for the Jordan Creek watershed that protects aquatic life, and since the aquatic life criteria are more stringent than levels needed to protect human health, the TMDL will also protect human health .

The most significant source of mercury to Jordan Creek is gold mining that occurred in the Silver City area between 1896 and the 1920s. Mercury was used in the mining operations to extract gold ore. Much of this mercury was lost to the streams and soils around historic mines.

Mercury from diffuse sources such as water runoff from land, is referred to as nonpoint source pollution. Nonpoint source pollution from historic mining activity is the primary cause of water quality degradation in the Jordan Creek watershed. Though minor in comparison to nonpoint source pollution, end-of-pipe wastewater discharges from point sources are also assessed in the TMDL, which sets mercury limits for two point sources: Kinross-Delamar Mine's stormwater and groundwater remediation discharges.

TMDL implementation is carried out through two primary mechanisms: water quality discharge permits for point sources and water quality management plans for nonpoint sources. In Idaho EPA administers the water quality discharge permits. The IDEQ TMDL document included an implementation strategy for designated organizations that are prepared and carry out source-specific TMDL implementation plans,

primarily to address nonpoint sources. EPA does not have authority to establish or approve TMDL implementation plans.

Introduction

The federal Clean Water Act requires that states adopt water quality standards. State water quality standards must specify the designated uses for a water body and establish water quality criteria to achieve the designated uses. When setting water quality standards, a state must consider a water body's use and value for public water supplies, propagation of fish and wildlife, recreational purposes, and agricultural, industrial, and other purposes, as well as any use or value for navigation. When a state adopts or revises a water quality standard, the standard is submitted to the United States Environmental Protection Agency (EPA) for approval. Upon EPA approval, the state water quality standard becomes the federally recognized Clean Water Act standard for the applicable water body.

In addition, Section 303(d) of the Clean Water Act requires states to identify and prioritize water bodies that are water quality limited (i.e., water bodies that do not meet the state's water quality standards). States must periodically publish a priority list of impaired waters, which are typically referred to as a state's 303(d) list. For waters identified on the 303(d) list, the Clean Water Act requires states to develop a total maximum daily load (TMDL) for pollutants that cause impairment. Loading limits in a TMDL are set at a level expected to attain water quality standards. EPA must approve or disapprove a state's TMDLs. If EPA disapproves a state TMDL, then EPA must issue a TMDL that is expected to attain water quality standards.

The State of Idaho Department of Environmental Quality (IDEQ) issued three TMDLs for Jordan Creek on June 4, 2010. The Jordan Creek TMDLs addressed waters impaired for temperature, sediment and mercury. On April 13, 2011, EPA disapproved the mercury TMDL for Jordan Creek because the proposed pollutant loadings were insufficient to attain water quality standards. Specifically, the mercury TMDL failed to meet the aquatic life water quality criterion for chronic exposure (i.e., 0.012 µg/l) to mercury. Consequently, EPA proposes to issue this revised mercury TMDL for Jordan Creek.

This document is organized as follows:

1) Watershed Background provides an overview of the Jordan Creek geography and setting and describes the climate and hydrology of the watershed.

2) Water Quality Limited Segments examines the status of Idaho's 303(d) listed waters and defines the extent of mercury impairment.

3) Applicable Water Quality Standards describes the beneficial uses Jordan Creek supports and Idaho's mercury criteria to protect those uses. This section also describes the water quality standards that apply in downstream waters in Oregon.

4) Evaluation and Study of Mercury Contamination in Jordan Creek describes the mercury data collected and analyzed in the TMDL area. This section also discusses mercury's properties as a pollutant.

5) Pollutant Source Inventory discusses the causes of water quality limitation for mercury-affected areas of Jordan Creek.

6) Total Maximum Daily Loads quantifies pollutant sources and allocates responsibility for load reductions needed to return impaired waters to a condition attaining water quality standards and supporting beneficial uses.

1. Watershed Background

1.1. Watershed Description

The Jordan Creek watershed (or subbasin), hydrologic unit code (HUC) 17050108, is located in southwest Idaho and southeast Oregon (Figure 1-1). The headwaters of Jordan Creek originate in the western section of the Owyhee Mountains in southwest Idaho. Jordan Creek flows west and crosses into the Jordan Valley in Oregon and into the Owyhee River near Rome, Oregon. The Jordan Creek subbasin area is 1,275 square miles, with a population just under 600 people in 2000. The only town in the subbasin is Jordan Valley (pop. 228), located on the Oregon side of the Oregon-Idaho state line. Jordan Valley is located along Jordan Creek. There are no Indian reservations within the watershed.

Land uses in the Jordan Creek watershed consist of irrigated agriculture, rangeland, forest and mining. Land ownership is a mix of private, federal, and state managed lands. The majority of people live on small homesteads, ranches, and farms scattered throughout the watershed (Figure 1-2). Jordan Valley, Oregon, is the only municipality with permanent year-round residents. The historic town of Silver City, Idaho, is composed mostly of part-time or weekend residents.
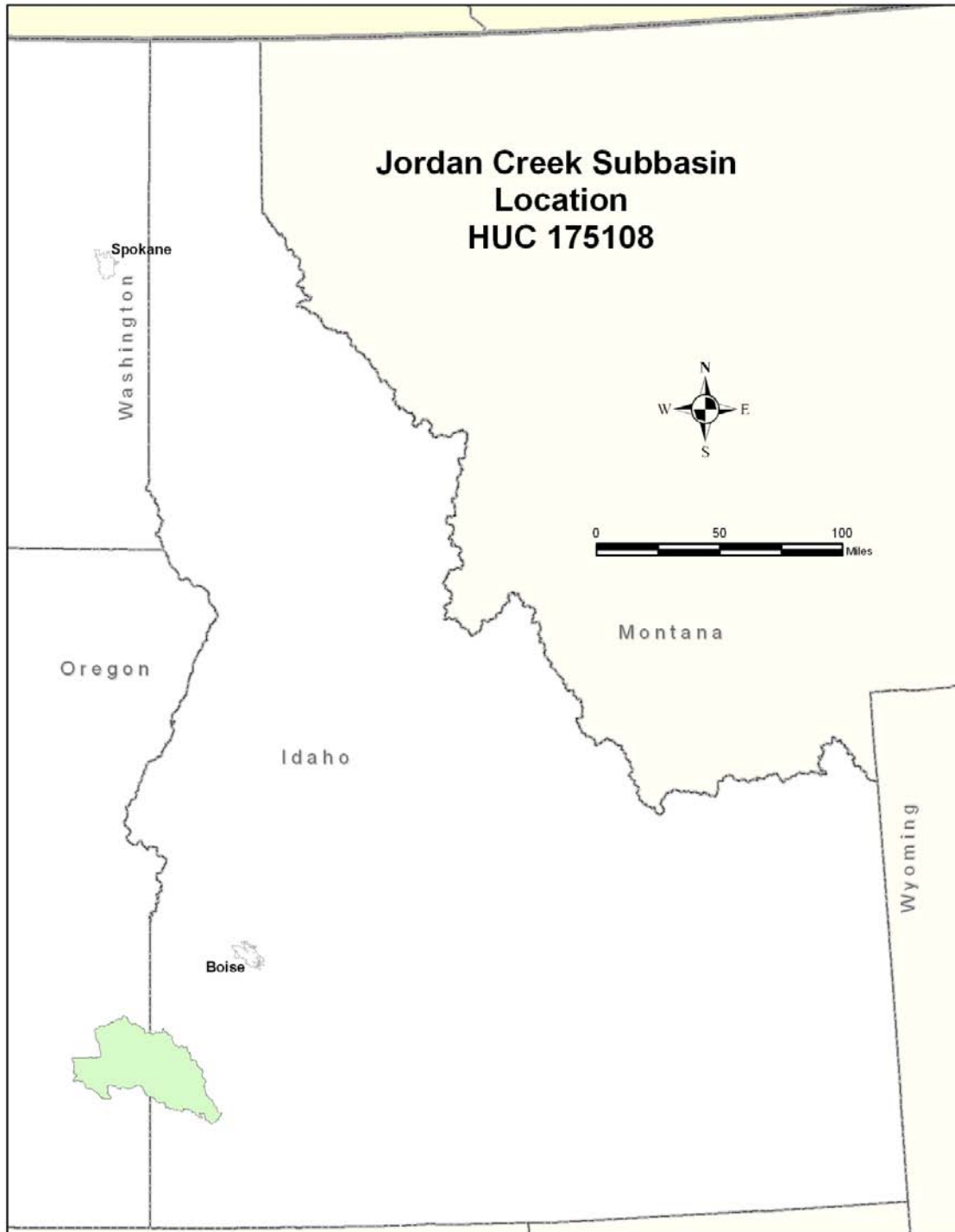
Figure 1-1. Location of Jordan Creek watershed.
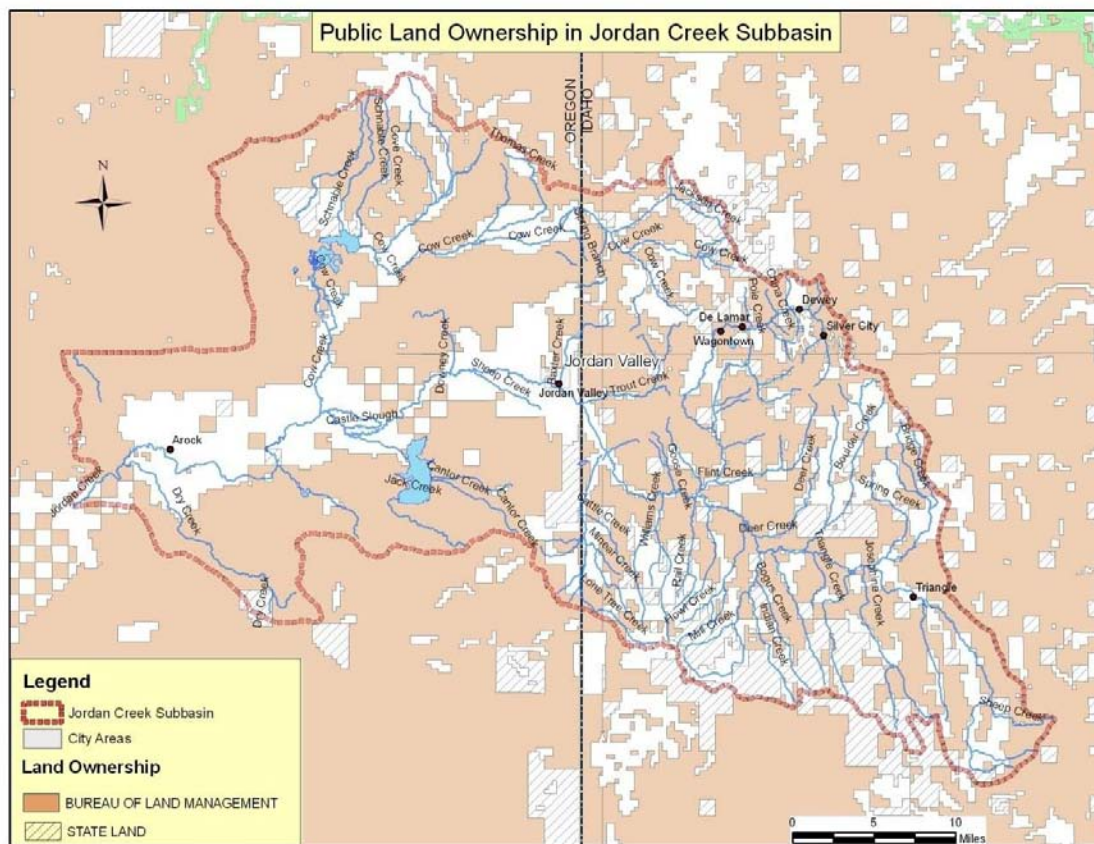
Figure 1-2. Land ownership in Jordan Creek subbasin.

1.2. Climate

There is one Idaho climate monitoring station within the Jordan Creek watershed: Silver City (Station # 108412). Other stations within the watershed are located in Oregon and include Sheaville, Oregon (Station # 357736); Rocksville 5N, Oregon (Station # 357277); and Danner, Oregon (Station # 352135). Additional climate monitoring sites outside the watershed include Reynolds, Idaho (Station # 107648); Grandview 2W, Idaho (Station # 103760); Bruneau, Idaho (Station # 101195); and Owyhee Dam, Oregon (Station # 356405) (Climatic Service Center, Internet retrieval 2004).

The Oregon stations within the watershed reflect weather conditions in the lower elevations (3,670–4,580 feet/1,118–1,395 meters), while the only climate station within Idaho represents the climatic conditions in the upper elevations (6,190 feet/1,900 meters). Table 1-1 shows the climatic summary for the climate stations in the watershed. Figure 1-3 shows the expected precipitation pattern.

There is a sharp contrast between the amount of precipitation in the lower elevations and the higher elevations of the watershed. Silver City, located at 6,100 feet (1,900 meters), receives almost double the annual average precipitation of the stations located below 5,000 feet. Sharp changes in precipitation pattern affect vegetation patterns. For example, isolated stands of Douglas fir (Psueudotsuga menziesii), which have higher water requirements, dominate the landscape near Silver City (elevation 6,100 feet), while low sagebrush (Artemisia arbuscula) communities, which have lower water requirement, dominate landscape near the Oregon state line and Jordan Valley (elevation 4,390 feet).

Table 1-1. Climatic Summary for the Jordan Creek Watershed (Western Regional Climatic Center 2004)

Station and Station Identification	Silver City, Idaho (Station # 108412)	Sheaville, Oregon (Station # 357736)	Danner, Oregon (Station # 352135)	Rocksville 5N, Oregon (Station # 357277)
Elevation (meters)	1,877	1,396	1,320	1,146
Elevation (feet)	6,160	4,580	4,330	3,760
Max Average Temp, June thru September (ºF/ ºC)	55.7/13.2	60.8/16.0	83.5/28.6	62.6/17.0
Min Average Temp, June thru September (in ºF/ ºC)	35.4/1.9	31.9/-0.1	43.0/6.1	31.3/-0.4
Average Precipitation (inches)	20.9	13.5	11.6	11.6
Average Snow Accumulation (inches)	80.9	35	25.2	17.3
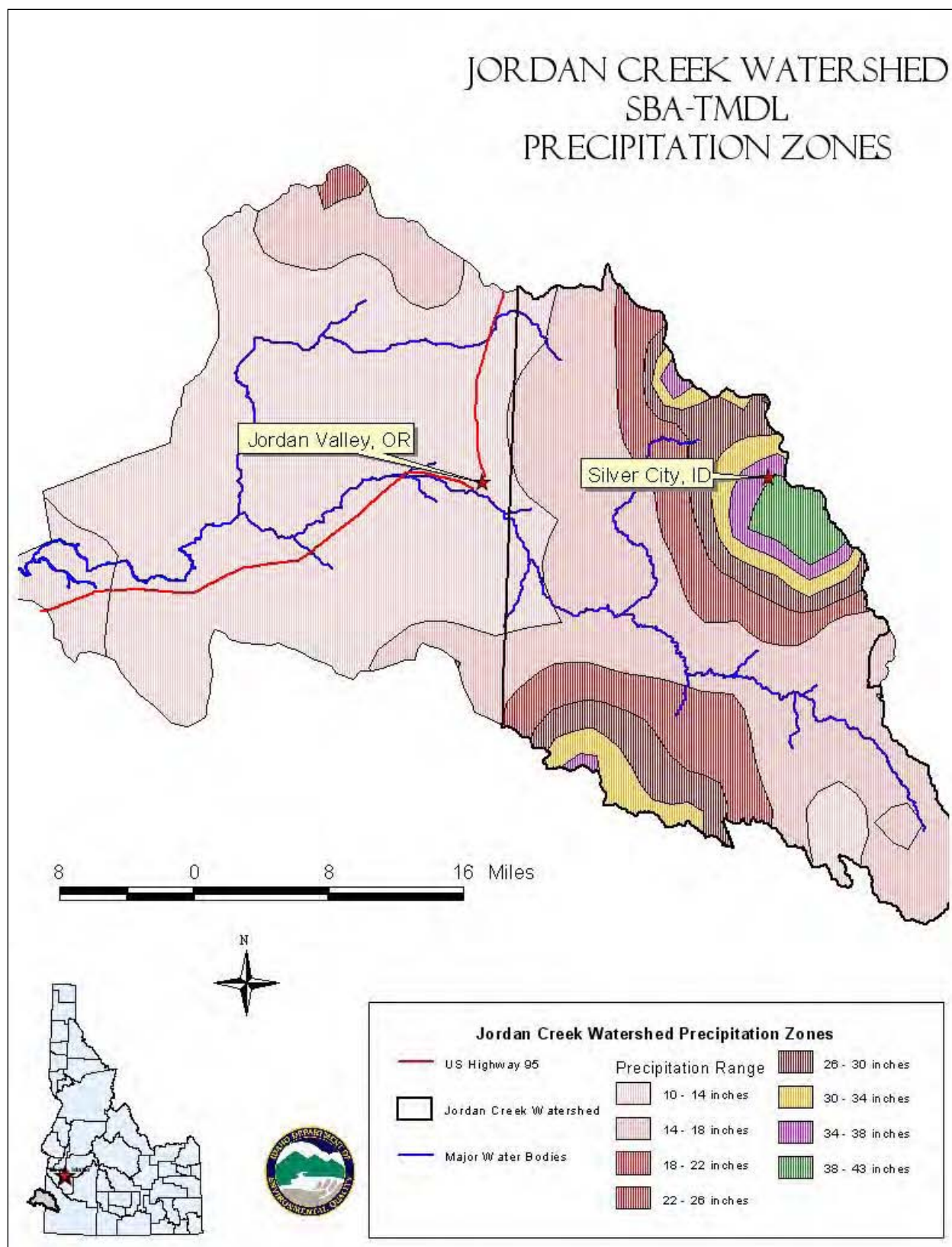
Figure 1-3. Precipitation ranges for Jordan Creek watershed.

1.3. Discharge (Flow) Characteristics

The United States Geological Survey (USGS) operated one discharge measurement gage in the upper Jordan Creek watershed from 1993 through 1996 (USGS 13177985), and another gage in the lower Jordan Creek watershed from 1945 through 1971 and from 2002 through 2003 (USGS 13178000). Data from these gages demonstrate the "flashy" flow dynamics in Jordan Creek. Monthly averages for the period recorded in upper Jordan Creek included "zero" discharge for two months in 1994 and peak flows exceeding 200 cubic feet per second (cfs) in May 1995 and 1996; but they also demonstrate a low discharge of less than 50 cfs for the same month in 1994. The highest monthly average discharge recorded at the lower Jordan Creek site was 2,098 cfs in April 1952; the lowest monthly average discharge recorded was 1.2 cfs in September 1962. Peak discharge usually occurs in April, but discharges in the 1,000 cfs range can occur anytime from January through June.

For upper Jordan Creek, Figure 1-4 shows average monthly discharge for the USGS gage (USGS 13177985) below Delamar. For lower Jordan Creek, Figure 1-5 shows average monthly discharge for the USGS gage (USGS 13178000) upstream of Lone Tree Creek.
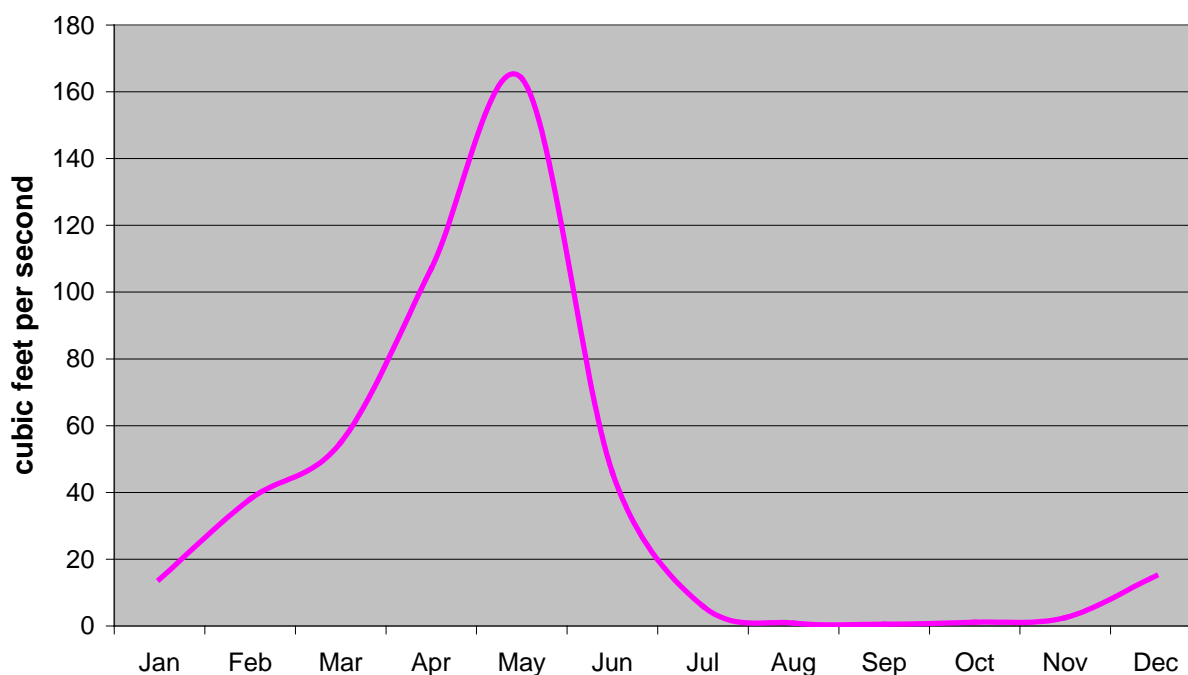
Figure 1-4. Average monthly measured discharge for Upper Jordan Creek below Delamar; data from 1993 - 1996 (USGS 13177985).
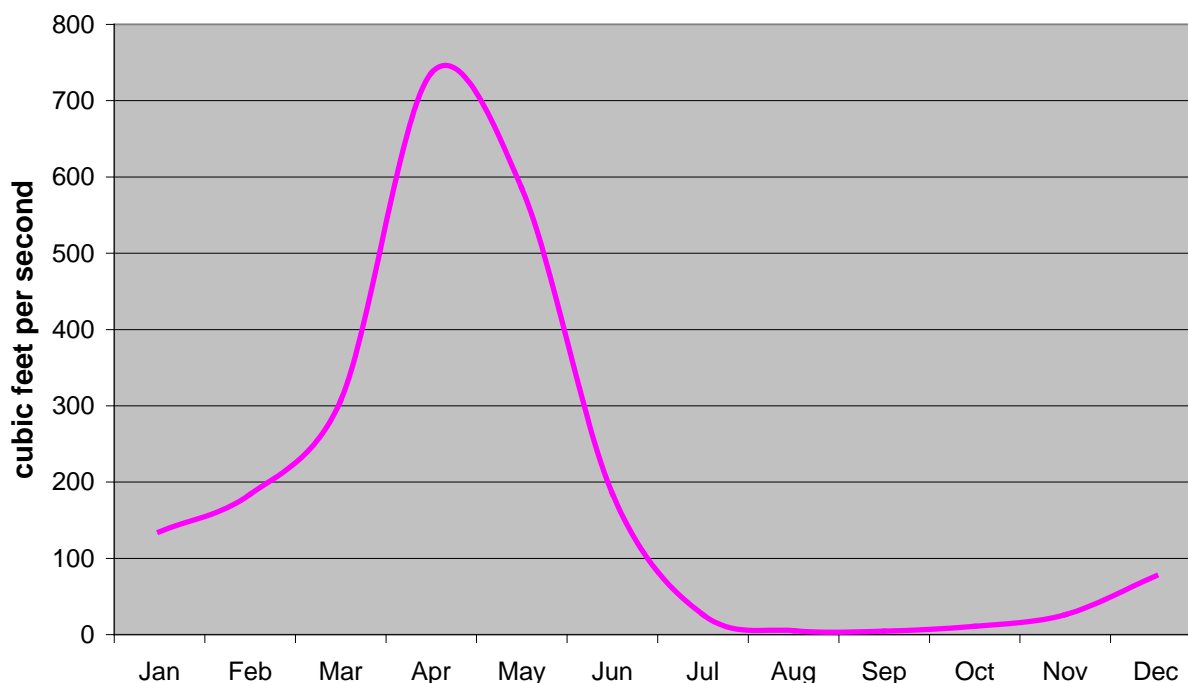
Figure 1-5. Average monthly measured discharge for Lower Jordan Creek above Lone Tree Creek; data from 1945 - 2004 (USGS Gage 13178000).

Instantaneous discharge data and other predictive discharge models for Jordan Creek are numerous and are well documented from 1988 through the present. The most comprehensive information is found in the Stone Cabin Mine, Final Environmental Impact Statement (EIS) (CH2M Hill 1994). The EIS presents data from 1988 through 1992.

2. Water Quality Limited Segments

Idaho's most recent Clean Water Act 303(d) list includes four assessment units[1] (AUs) in the Idaho portion of the Jordan Creek drainage listed as impaired because of mercury.

Table 2-1 and Figure 2-1 show the impaired areas. The original listing for impairment on the state's 303(d) list for 1998 was for the main stem of Jordan Creek from Williams Creek upstream to the headwaters. There is no information on the basis for the original listing. In addition, there were some errors when segments of Jordan Creek were translated to AUs for the 2002 listing cycle. Consequently, an unimpaired segment (ID17050105SW001_02) was included on the 303(d) list, and two impaired segments (ID17050108SW004_04 and ID17050108SW001_05) were erroneously left off the list.

Figure 2-1 also shows waters listed in Oregon as impaired for mercury. The Oregon listings include Jordan Creek from the Idaho border to its confluence with the Owyhee River and Antelope Reservoir, which has as its major source of water a diversion from Jordan Creek near the Idaho border. The Owyhee River downstream of Jordan Creek confluence is also listed as impaired for mercury for 100 miles downstream.

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[1] Idaho uses AUs to represent groups of similar streams that have similar stream order, land use practices, ownership, or land management. AUs are used as the framework for listing impaired waters in Idaho.

Table 2-1. Jordan Creek Subbasin Mercury Impaired Waters in Idaho

3. Assessment Unit/ Segment ID	4. Waterbodies	303(d) List			Previous Segment ID	Status
		1998	2002	2008		
ID17050108SW001_02	1st and 2nd order Jordan Creek tributaries downstream of Williams Creek		X	X		Listed in error, no evidence of impairment: recommend delist
ID17050108SW004_02	1st and 2nd order Jordan Creek tributaries upstream of Williams Creek including Jordan Creek upstream of Jacobs Gulch	X	X	X	2649	Impaired and Listed; Addressed by TMDL
ID17050108SW004_03	Jordan Creek between Louse Creek and Jacobs Gulch - 3rd order	X	X	X	2649	Impaired and Listed; Addressed by TMDL
ID17050108SW004_05	Jordan Creek between Big Boulder Creek and Williams Creek - 5th order	X	X	X	2649	Impaired and Listed; Addressed by TMDL
ID17050108SW004_04	Jordan Creek – Louse Creek to Williams Creek	X			2649	Unlisted Impaired; Addressed by TMDL
ID17050108SW001_05	Jordan Creek - Williams Creek to Oregon Border				2648	Unlisted Impaired; Addressed by TMDL

There is no explicit information on the basis for the Jordan Creek mercury listing, though there is ample data extending back to the early 1970s documenting high concentrations of mercury in fish from Jordan Creek. Fish tissue collected in 2005 in upper Jordan Creek exceeded the mercury criterion of 0.3 mg/kg. IDEQ was unable to collect adequate samples of fish from the lower portion of Jordan Creek during the 2005 study, however, the predictive model used to estimate mercury levels in fish for lower Jordan Creek indicates an exceedance of the fish tissue criterion of 0.3 mg/kg (IDEQ 2010).

Water column samples of total mercury exceed the aquatic life chronic exposure criterion of 0.012 µg/l at all locations sampled in Jordan Creek from Silver City to the Oregon border. Additional water and sediment samples provided data confirming the presence of high concentrations of total mercury, dissolved mercury and methylmercury in the headwaters near historic mining activity to the Oregon border.

This TMDL for mercury addresses the elevated levels of mercury in Jordan Creek waters and fish tissue. This TMDL only applies those water bodies in Idaho.
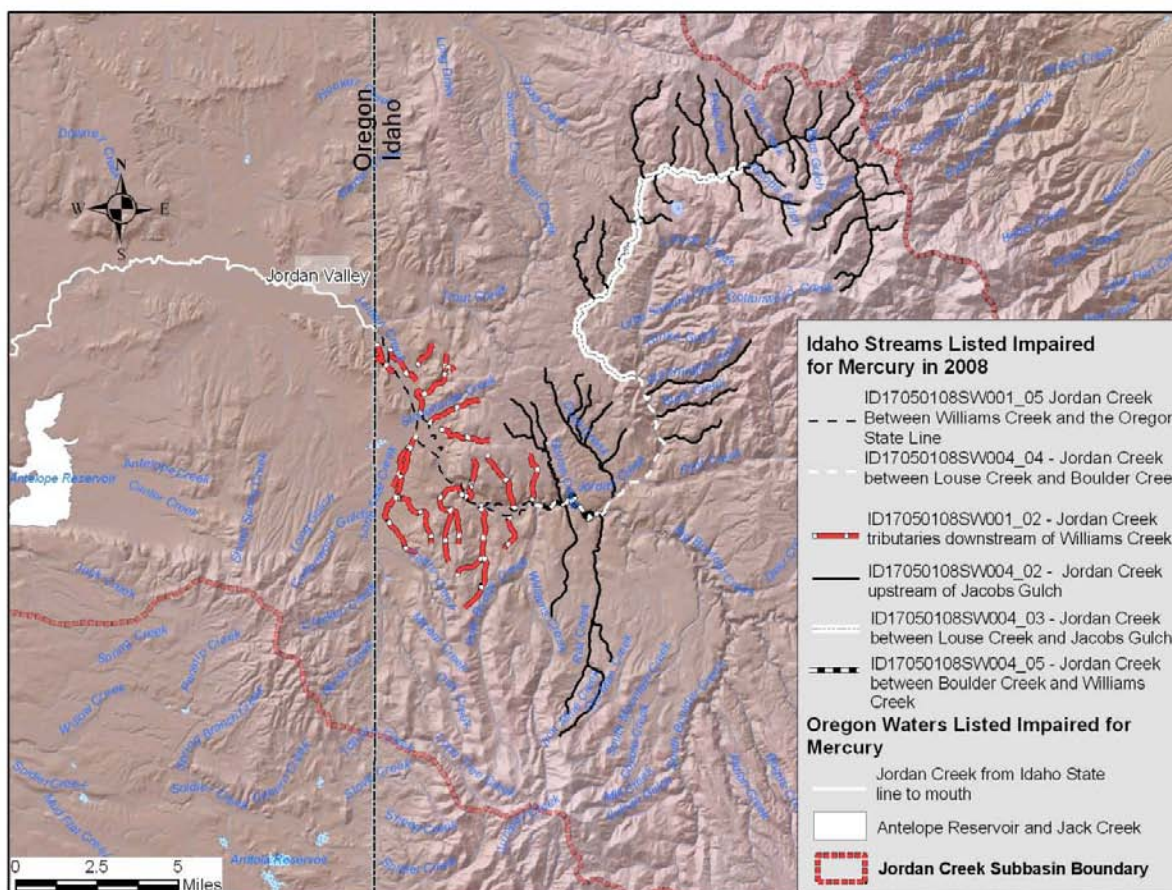
Figure 2-1. Waters 303(d)-listed for mercury in Jordan Creek Subbasin.

3. Applicable Water Quality Standards

3.1. Beneficial Uses

Idaho water quality standards require that surface waters of the state are protected for beneficial uses wherever attainable (IDAPA 58.01.02.050.02). A list of the beneficial uses for 303(d)-listed streams in the Jordan Creek subbasin is provided in Table 5-1. Beneficial uses affected by mercury pollution include recreation, in the form of fishing, and cold water aquatic life. The recreational fishing use is affected because elevated levels of mercury in fish may impact human health and reduce the amount of fish that can be safely consumed. Fish and other aquatic species can also be adversely affected by exposure to mercury in the food chain, thus affecting cold water aquatic life beneficial uses. Idaho Department of Health issued a fish consumption advisory for fish from Jordan Creek in 2007 (Figure 5-1). There are also fish consumption advisories for downstream waters in Oregon, as shown in Figure 5-2.

Special Resource Waters and Salmonid Spawning are also beneficial uses for some of the impaired waters in Jordan Creek. Although mercury pollution may impact these uses, they are not the primary beneficial uses affected by mercury impairment.

Table 5-1. Beneficial Uses of 303(d)-listed Streams in Jordan Creek Subbasin

Waterbody Description	Assessment Unit ID	Designated Use	IDAPA Section
Jordan Creek – Williams Creek to Idaho/Oregon Stateline	ID1705108SW001_02 ID1705108SW001_05 (unlisted)	▪ Cold Water Aquatic Life ▪ Salmonid Spawning ▪ Primary Contact Recreation ▪ Special Resource Water	58.01.02.140.08. SW-1
Jordan Creek – Source to Williams Creek	ID1705108SW004_02 ID1705108SW004_03 ID1705108SW004_05 ID1705108SW004_04 (unlisted)	▪ Cold Water Aquatic Life ▪ Salmonid Spawning ▪ Primary Contact Recreation ▪ Special Resource Water	58.01.02.140.08. SW-4

Figure 5-1. Idaho Department of Health fish consumption advisory for fish from Jordan Creek issued in 2007.

Jordan Creek Mercury TMDL *August 2011*

WATERBODY	CONTAMINANT & GUIDELINES
Antelope Reservoir and Jordan Creek (SE Oregon, Malheur County)	**Very high mercury levels** • Women ages 18-45, children under 6, pregnant and/or nursing women, and people with liver and kidney problems should avoid eating fish from these waters. • Healthy women beyond childbearing age (>45 years) and healthy adult males should eat no more than one meal per month of fish caught in these waters. • Mercury cannot be removed through cleaning or cooking methods. • <u>Sport-fishing & methylmercury</u>.
Owyhee Reservoir (SE Oregon, Malheur County)	**Very high mercury levels** • Women ages 18-45, children under 6, and people with liver and kidney problems should avoid eating fish from these waters. • Healthy women beyond childbearing age (>45 years) and healthy adult males should eat no more than one meal per month. • Mercury cannot be removed through cleaning or cooking methods. • Learn more about <u>Sport-fishing & methylmercury</u>.
Owyhee River (SE Oregon, Malheur County, upstream of Owyhee Reservoir to Three Forks)	**High mercury levels** • Children under 6 should eat no more than one meal every two months. • Women ages 18-45 should eat no more than one meal every month. • Healthy women beyond childbearing age (>45 years) and healthy adult males should eat no more than one meal every two weeks. • Mercury cannot be removed through cleaning or cooking methods. • Learn more about <u>Sport-fishing & methylmercury</u>.

Figure 5-2. Oregon Health Authority fish consumption advisories for mercury in Jordan Creek, Antelope Reservoir, the Owyhee River and Owyhee Reservoir, downstream of Idaho waters

3.2. Water Quality Criteria to Support Beneficial Uses

Table 5-2 presents applicable water quality criteria for mercury in Jordan Creek.

Table 5-2. Water Quality Criteria for Mercury

Parameter	Aquatic Life		Human Health for the consumption of organisms
	CMC[5] Acute Criterion	CCC[6] Chronic Criterion	
Mercury	2.1 µg/l [1]	0.012 µg/l [2,3]	
Methylmercury			0.3 mg/kg [4]

1. IDAPA 58.01.02.210.01 (IAC2004); Criteria for these metals are expressed as a function of the water effect ratio WER, as defined in subsection IDAPA 58.01.10.210.03.c.iii
2. IDAPA 58.01.02.210.01 (IAC2004); Criterion expressed as total recoverable (unfiltered) concentrations.
3. If the chronic criterion for mercury is exceeded more than once in a three year period in ambient water, the edible portion of aquatic species of concern must be analyzed to determine whether the concentration of mercury exceeds the Food and Drug Administration (FDA) action level (one (1.0) mg/kg. If the FDA action level is

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exceeded, the director of IDEQ must notify the EPA regional administrator, initiate a review and as appropriate, revision of its mercury criterion in these water quality standards, and take other appropriate action such as the issuance of fish consumption advisory for the affected area.

4. IDAPA 58.01.02.210.01 (IAC2010); This fish tissue residue criterion (TRC) for methylmercury is based on a human health reference dose (RfD) of 0.0001 mg/kg body weight-day; a relative source contribution (RSC) estimated to be 27% of the RfD; a human body weight (BW) of 70 kg (for adults); and a total fish consumption rate of 0.0175 kg/day for the general population, summed from trophic level (TL) breakdown of TL2 = 0.0038 kg fish/day + TL3 = 0.0080 kg fish/day + TL4 = 0.0057 kg fish/day. This is a criterion that is protective of the general population. A site-specific criterion or a criterion for a particular subpopulation may be calculated by using local or regional data, rather than the above default values, in the formula: TRC = [BW x {RfD – (RSCxRfD)}] / TL. In waters inhabited by species listed as threatened or endangered under the Endangered Species Act or designated as their critical habitat, the Department will apply the human health fish tissue residue criterion for methylmercury to the highest trophic level available for sampling and analysis.

5. IDAPA 58.01.02.003.21 (IAC2004) Criterion Maximum Concentration (CMC), unless otherwise specified in these rules, the maximum instantaneous or one (1) hour average concentration of a toxic substance or effluent which ensures adequate protection of sensitive species of aquatic organisms from acute toxicity resulting from exposure to the toxic substance or effluent. The CMC will adequately protect the designated aquatic life use if not exceeded more than once every three (3) years. The terms "criterion maximum concentration" and "acute Criteria" are equivalent.

6. IDAPA 58.01.02.003.20 (IAC2004) Criterion Continuous Concentration (CCC), unless otherwise specified in these rules, the four (4) day average concentration of a toxic substance or effluent which ensures adequate protection of sensitive species of aquatic organisms from chronic toxicity resulting from exposure to the toxic substance or effluent. The CCC will adequately protect the designated aquatic life use if not exceeded more than once every three (3) years. The terms "criterion continuous concentration" and "chronic Criterion" are equivalent.

3.3. *Downstream Water Quality Standards in Oregon*

The State of Oregon criteria as approved by EPA for mercury are described in Table 5-3. Oregon has no human health criterion for mercury. On June 6, 2011the state adopted new criteria for protection of human health that will become effective upon EPA approval.   EPA is currently reviewing these proposed standard changes.

Table 5-3. Oregon Water Quality Criteria for Mercury in Jordan Creek[a]

Parameter	Protection of Aquatic Life - Acute Exposure	Protection of Aquatic Life - Chronic Exposure	Protection of Human Health - Water and Fish Ingestion	Protection of Human Health – Fish Ingestion Only	Drinking Water
Mercury	2.4 µg/l	0.012 µg/l	WITHDRAWN[b]	WITHDRAWN	0.002mg/l

a. Effective Water Quality Criteria for Human Health OAR 340-041-0033 (Effective June 1, 2010)
b. The most recent EPA-approved human health criteria for mercury in Oregon's standards were 0.144 ug /l for water and fish ingestion and 0.146 ug /l for just fish ingestion.

4. Evaluation and Study of Mercury Contamination in Jordan Creek

Mercury is a naturally occurring, chemically active element, which is pervasive in both environmental media and biota. As it cycles through the atmosphere, land, and water, mercury undergoes a series of complex chemical and physical transformations, many of which are not completely understood. Mercury's cycle in the environment is a result of both natural and human activities. Additionally, mercury accumulates in the aquatic food web.

Inorganic mercury exists in several oxidation states: elemental (quicksilver) and mercury salts. Elemental mercury is a heavy, mobile, liquid metal at ambient temperatures. Virtually insoluble in water, elemental mercury is volatile. The vaporization rate of elemental mercury approximately doubles for every 10 degrees Celsius (ºC) increase in temperature (MDEP 1996).

Methylmercury is an organic mercury compound that is somewhat soluble in water. Inorganic mercury can be methylated by microorganisms in soil, sediment, and water to form methylmercury. Microbial processes can also lead to demethylation, where methylmercury reduces back to elemental mercury.

Elemental mercury is the most common form of mercury found in the atmosphere. Inorganic mercury salts adhere to soil particulates much more than methylmercury or elemental mercury. Therefore, relative to the other forms of mercury, elemental mercury partitions much more strongly to the atmosphere. Inorganic mercury salts and methylmercury partition much more strongly to sediments and water, respectively.

Although most of the mercury in aquatic systems is in the inorganic form, more than 95% of the mercury accumulated by fish is methylmercury (USEPA 1997). The elimination of methylmercury by fish is very slow relative to the rate of uptake, which allows the pollutant to accumulate in fish tissue (Laarman et al. 1975 and McKim et al. 1976). Inorganic mercury, which is absorbed as readily as methylmercury, is removed by organisms at a much faster rate (Hildebrand et al. 1980a and 1980b). Therefore, almost all of the mercury found in animal tissues is in the form of methylmercury (USEPA 1997).

Bioavailability of methylmercury is determined by a combination of physicochemical characteristics of the aquatic system, the amount and rate of mercury loading, and the structure and function of the food web within the system. Methylmercury is one of the most highly toxic forms of mercury and is also the one which accumulates in the aquatic food chain. Therefore, humans and wildlife dependent on aquatic food sources are particularly at risk because of the potential for methylmercury to bioaccumulate in fish.

There have been several investigations of mercury pollution in Jordan Creek. Studies by Gebhards et al. (1971), Hill et al. (1973), IDEQ (1980), CH2M Hill (1994), USEPA (1998), and Dai and Ingham, (2006) all found high mercury concentrations in various media in the area and concluded that mercury was a concern for water quality and/or public health. This section discusses the results of the most recent study of mercury in the Jordan Creek watershed, which was completed by IDEQ in 2005 (Ingham 2005). This TMDL relied on the Dai and Ingham (2006) study because it:

- contains the most recent data;
- is the only study with paired, simultaneous sampling of mercury in fish tissue, water and sediment;
- is the only study with detection limits sensitive enough to determine whether the water column criterion for aquatic life was exceeded;
- is the only study with information on methymercury; and
- includes data from both reference sites unaffected by legacy mining and sites contaminated by mercury downstream of the Silver City historic mining district in Jordan Creek.

The IDEQ study only collected data in one round of sampling during the low water season in August 2005. The main problem with this study is that it does not contain information on mercury during other seasons or flow conditions. The results from this study to evaluate mercury impairment in fish tissue, water and sediment in the TMDL area are discussed in the last three sub-sections of this section.

4.1. Mercury and Fish Tissue

IDEQ conducted fish tissue sampling in 2005 at eight sites in the Jordan Creek watershed—fives sites on Jordan Creek and three sites on tributaries. Samples were collected at four sites in upper Jordan Creek—Jordan Creek below Silver City (JC-2005-11), Jordan Creek below Henrietta Gulch (JC-2005-09), Jordan

Creek below historic dredge tailings (JC-2005-08) and Jordan Creek below Boulder Creek (JC-2005-02). No desirable-catchable-edible fish were found in the lower segment of Jordan Creek (JC-2005-01).

The specifics of collection methods, targeted species, fish preparation and analytical methods are discussed in *Quality Assurance Project Plan, Jordan Creek Watershed HUC 1705108 mercury Monitoring Project July-September 2005* (Jordan Creek QAPP) (Ingham 2005). Data results and statistical analysis for all study sites are outlined in *Analysis of Total Mercury Concentrations in Fish Samples from Jordan Creek and Non-Jordan Creek Sites* (Dai and Ingham 2006).

Table 6-1shows that almost all of the fish tissue samples IDEQ collected in 2005 exceeded the 0.3-mg/kg criterion. Figure 6-1 shows the sites where fish were collected for the samples. The *Implementation Guidance for the Idaho Mercury Water Quality Criteria* (IDEQ 2005) provides a formula for calculating the average mercury concentrations in fish tissue, factoring in consumption by trophic level. Using that approach, the weighted average based on trophic level for all of the upper Jordan Creek sites is 0.534 mg/kg.

Table 6-1. Fish Tissue Results for Upper Jordan Creek Sites (IDEQ 2010)

Station	Sample Type	Species	Mercury Fish Tissue Level (mg/kg)
JC-2005-02 Jordan Creek Below Boulder Creek	WB-COMP[1]	Sucker	0.783
	WB-COMP	Red sided shiner	0.526
	WB-COMP	Chisel mouth sucker	0.502
	WB-COMP	Dace	0.687
	WB-COMP	Northern Pike Minnow	0.777
	WB-COMP	Sucker	0.574
	WB-COMP	Long nose dace	0.429
	WB-COMP	Red sided shiner	0.525
	WB-COMP	Bridge lip sucker	0.605
	WB-COMP	Sculpin	0.488
		Average	0.59
JC-2005-08 Jordan Creek below Placer Tailings	WB-COMP	Dace	0.5
	WB-COMP	Dace	0.532
	COMP-IND[2]	Redband trout	0.356
	COMP-IND	Redband trout	0.417
	WB-COMP	Northern Pike Minnow	0.437
	WB-COMP	Sucker	0.772
	COMP-IND	Sucker	0.146
	WB-COMP	Red sided shiner	0.531
		Average	0.461
JC-2005-09 Jordan Creek Below Delamar Mine	WB-COMP	Dace	0.589
	COMP-IND	Redband trout	0.246
	COMP-IND	Redband trout	0.578
	COMP-IND	Redband trout	0.572
	COMP-IND	Redband trout	0.448
	COMP-IND	Sucker	0.737

Station	Sample Type	Species	Mercury Fish Tissue Level (mg/kg)
		Average	0.527
JC-2005-11 Jordan Creek below Silver City	COMP-IND	Redband trout	0.552
	COMP-IND	Redband trout	0.481
	COMP-IND	Redband trout	0.688
	WB-COMP	Redband trout –Young of the Year	0.485
		Average	0.551

1. Whole Body Composite Sample
2. Individual Fillets Composite Samples
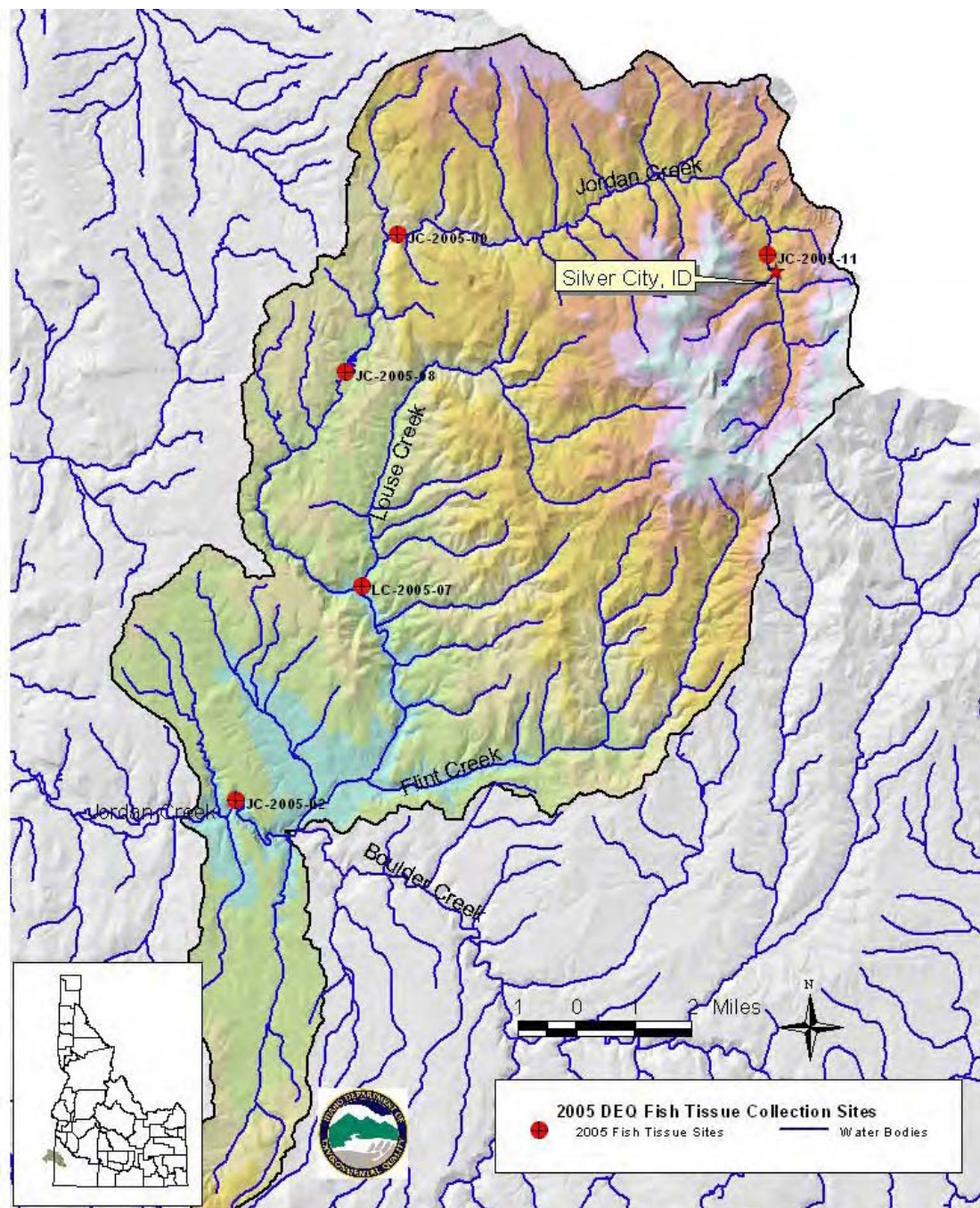
Figure 6-1. IDEQ 2005 fish tissue collection sites.

The statistical evaluation of the data indicates there is no significant difference between fish tissue mercury levels at the sampling sites in Jordan Creek, nor is there a pattern of increasing levels from downstream sites to upstream sites or upstream to downstream sites (Dai and Ingham 2006).

Other conclusions were:

- The average fish total mercury concentration at Jordan Creek sites is 0.56 mg/kg, while fish samples from the tributary sites had an average mercury concentration of 0.13 mg/kg.

- In Jordan Creek, the average total mercury concentration in redband trout, young of year, whole body composites samples was 0.49 mg/kg. At the Jordan Creek tributary sites, the average total mercury concentration of redband trout (young of year, whole body composites) was 0.03 mg/kg.

- Total mercury concentrations in redband trout at Jordan Creek sites in 2005 were significantly higher than in 1973 ($p < 0.001$) (Hill et al. 1973). However, no statistical difference was found in the fish mercury level between 2005 and 1973 for the Jordan Creek tributary sites ($p = 0.60$).

- Total mercury concentrations in Jordan Creek redband trout are predictable, provided the methylmercury concentrations of the water and the sediments are known. Fish weights and lengths are also good predictors for mercury levels in Jordan Creek. In the Jordan Creek tributary sites, fish size does not have a significant correlation with fish mercury levels.

As mentioned previously, no game fish were found in the lower segment of Jordan Creek at station JC-2005-01. Those fish that were collected weighed only a few grams, and none were classified as a game fish to be caught and consumed within Idaho. This does not rule out the possibility that large fish are present in lower Jordan Creek. At the Pleasant Valley Bridge, numerous large suckers and trout were observed in an area impounded by an in-stream diversion (Personal Observation, Ingham 2005).

To offset the lack of data and provide an estimate of mercury tissue concentrations, various best-fit models were applied using data from fish tissue, water samples and sediment samples collected in other parts of the watershed in 2005 as well as the fish tissue data from Hill et al. (1973). A complete analysis of models developed and used is described in *Analysis of Total mercury Concentrations in Fish Samples from Jordan Creek and Non-Jordan Creek Sites* (Dai and Ingham 2006). The results of the predictive model are shown in Table 6-2. If the predictive model is representative of mercury levels in fish in lower Jordan Creek, this would be an exceedance of the fish tissue criterion of 0.3 mg/kg.

Table 6-2. Estimated Mean Total Mercury Concentrations in Redband Trout at Jordan Creek Site JC-2005-01 (Dai and Ingham 2006)

Statistical Evaluation	Estimated Mercury Concentration in Redband Trout (mg/kg)
Mean	0.75
Lower 95% limit	0.61
Upper 95% limit	0.9

In conclusion, the mercury fish tissue data for 2005 show an exceedance of the state's mercury criterion for protection of human health. The results also supported issuance of the fish consumption advisory for Jordan Creek as described above.

4.2. Mercury and Water Quality

Historic water quality data for mercury in upper Jordan Creek were analyzed using detection limits of 0.1 μg/l or greater, well above Idaho's chronic aquatic life criterion of 0.012 μg/l. There were occasional detections reported above the detection limits. Most water quality data presented by Hill et al. (1973) showed that water column concentrations were below detectable levels of 0.2 parts per billion (ppb), (0.2 μg/l). The *Study of mercury and heavy metals in Jordan Creek drainage, Silver City Project* (Hill et al. 1973) provides only a general description of sampling locations.

Other available data include the 1998 Superfund Technical Assessment and Response Team (START) study (USEPA 1998), which showed only one station with mercury concentrations above the detectable level, and the Stone Cabin Mine EIS (CH2M Hill 1994), which documents surface water monitoring for

various years from 1984 through 1992. Results reported in the Stone Cabin Mine EIS ranged from <0.7 μg/l to a maximum of 7 μg/l for dissolved mercury. More recent water quality data provided by Kinross Delamar for samples collected between 2004 and 2008 showed 5 samples out of 113 exceeded the detection limit, which was typically 0.1μg/l (KDMC 2003, 2004, 2005a, 2005b, 2006, 2007 and 2008).

For the 2005 water quality/sediment mercury sampling event by IDEQ, 11 sites in the watershed were selected for monitoring, including six located on Jordan Creek. Information on all monitoring sites, sampling methods, parameters, quality assurance/quality control (QA/QC), detection levels and analytical methods can be found in the Jordan Creek QAPP (Ingham 2005). The six Jordan Creek sites selected to have water quality and sediment sampling included all the fish tissue collection sites, plus an additional site on Jordan Creek below Blue Gulch (JC-2005-10). The 2005 study established detection limits at 0.00057 μg/l with a reporting limit of 0.005 μg/l. This represents a significant improvement over the 1973 detection limits for reportable/available data for total mercury, dissolved mercury, and methylmercury analysis. The results of this study for total recoverable mercury in are shown in Table 6-3. Figure 6-2, Figure 6-3, and Figure 6-4 present total mercury, dissolved mercury and methylmercury concentrations, respectively, from the 2005 study in Jordan Creek.

In conclusion, the mercury water column data for 2005 show an exceedance of the state's mercury criterion for protection of aquatic life.

Table 6-3. Total Mercury, Dissolved Mercury and Methylmercury Water Quality Results for August 2005 at Jordan Creek Sites

Station	Description	Total Mercury (μg/l)[1,2]	Dissolved Mercury (μg/l)[2]	Methylmercury (μg/l)
JC-2005-01	Jordan near Stateline	**0.0199**	0.00917	0.00206
JC-2005-02	Jordan Below Boulder Cr.	**0.0314**	**0.0133**	0.00192
JC-2005-08	Jordan Below Placer Tailings	**0.0133**	0.00523	0.00074
JC-2005-09	Jordan Below Delamar Mine	**0.0353**	**0.0195**	0.00123
JC-2005-10	Jordan Below Blue Gulch	**0.0579**	0.00828	0.00064
JC-2005-11	Jordan Below Silver City	**0.0927**	**0.0895**	0.00214

1. Includes the total of particulate and dissolved mercury species
2. Bold values exceed the aquatic life protection criterion
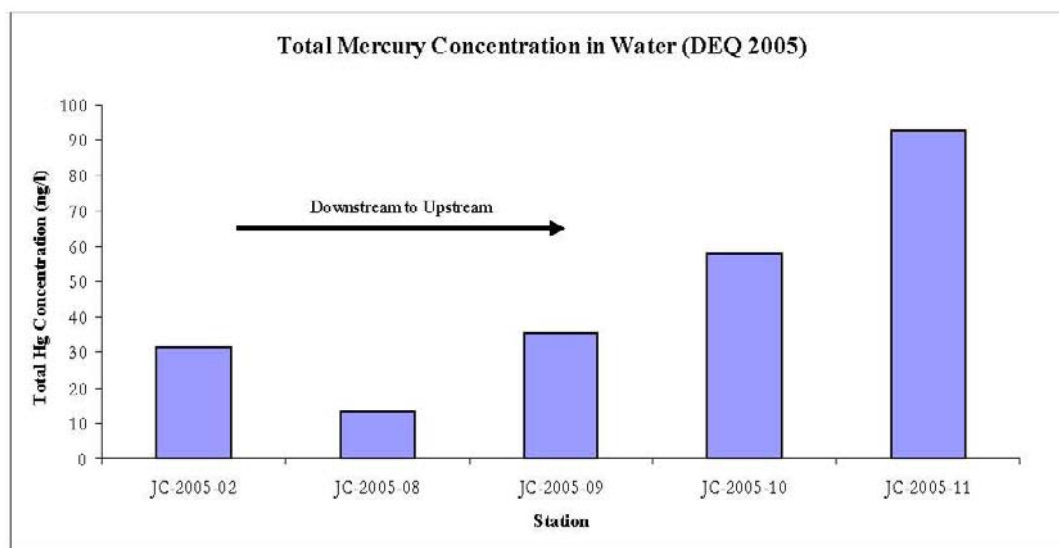
Figure 6-2. Total mercury concentration upper Jordan Creek watershed.
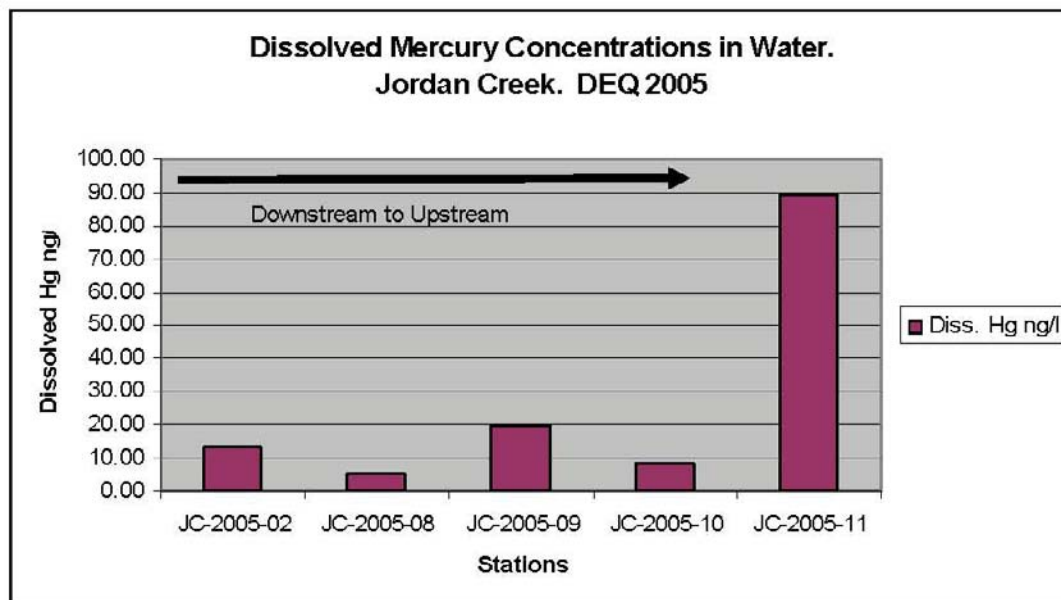
Figure 6-3. Dissolved mercury concentrations upper Jordan Creek watershed
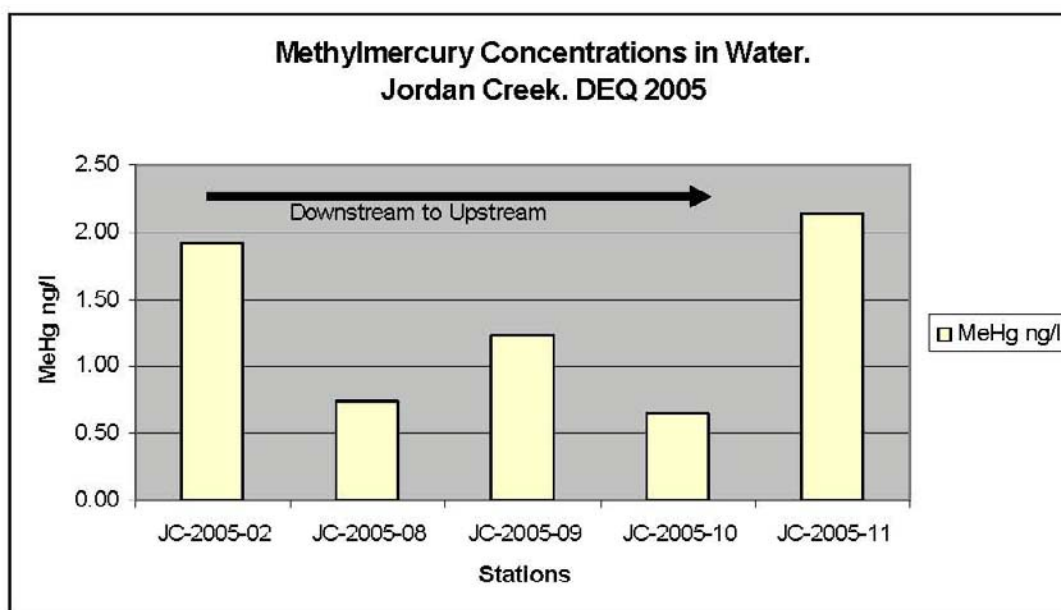
Figure 6-4. Methylmercury concentration upper Jordan Creek watershed

4.3. Mercury and Stream Sediments

The production of methylmercury from total mercury is a natural process that occurs mainly in stream sediments. In the methylmercury phase, mercury entrained in sediments becomes readily available for uptake by the lower trophic levels such as bacteria, periphyton and zooplankton, which are the primary food for the next trophic level and so forth up the food chain. Table 6-4 and Figure 6-5 present results of mercury concentrations in sediment from Jordan Creek sites from the 2005 study.

The State of Idaho does not have criteria to determine impairment in sediments. To better evaluate the mercury concentrations in sediment in Jordan Creek, data were compared to screening levels from the

National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables (SQuiRTs; Buchman 2008). Screening levels for freshwater sediments include the Threshold Effects Low (TEL), the concentration below which toxic effects are rarely observed in sensitive species; the Probable Effects Level (PEL), the concentration of mercury above which adverse effects to benthic organisms are likely; and the Significant Effects Level (SEL), the concentration at which pronounced disturbance of the sediment-dwelling community can be expected.

Table 6-4. Total Mercury and Methylmercury Results for Stream Sediments in Jordan Creek

Station	Description	Total Mercury (µg/g)	Threshold Effect Level (TEL)[1]	Probable Effect Level (PEL)[1]	Severe Effect Level (SEL)[1]	Methyl-mercury (µg/g)
JC-2005-01	Jordan near Stateline	4.26				0.0115
JC-2005-02	Jordan Below Boulder Cr.	2.046				0.0048
JC-2005-08	Jordan Below Placer Tailings	1.292	0.174 µg/g dry weight	0.486 µg/g dry weight	2.0 µg/g dry weight	0.0004
JC-2005-09	Jordan Below Delamar Mine	1.385				0.0319
JC-2005-10	Jordan Below Blue Gulch	1.235				0.00665
JC-2005-11	Jordan Below Silver City	0.948				0.00137

1.Total mercury concentrations for freshwater sediments from National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables (Buchman 2008)
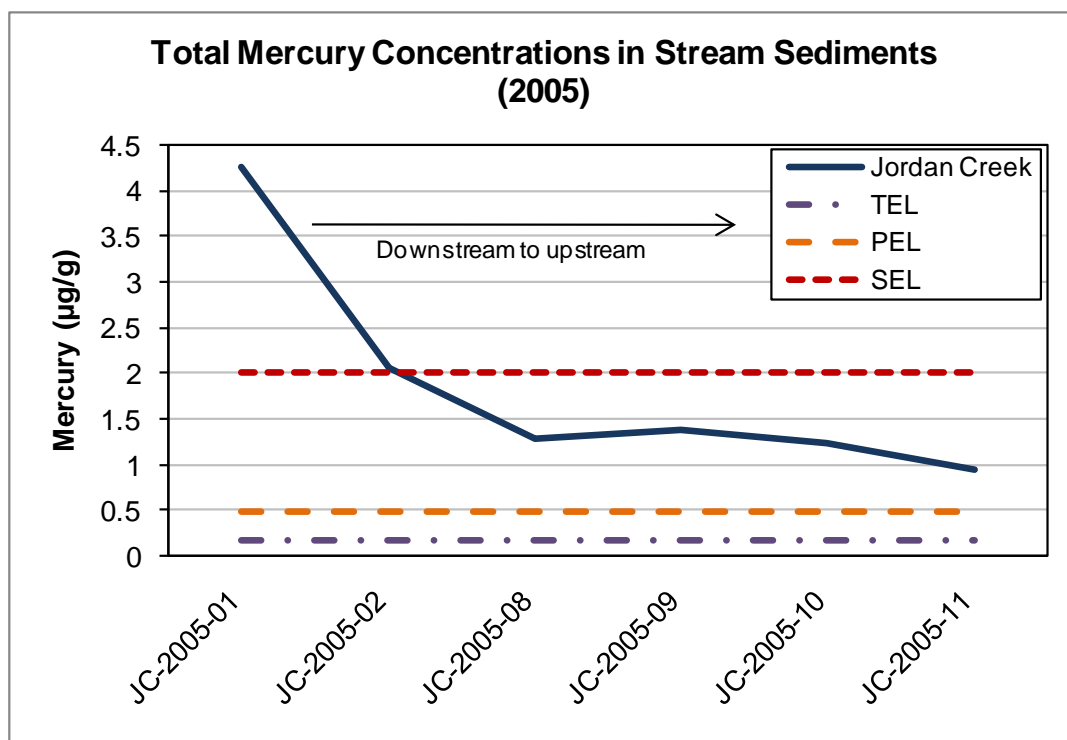
Figure 6-5. Total mercury concentrations in stream sediments from 2005 Jordan Creek sites.

The data show that mercury concentrations in sediment are over 1,000 times higher than the mercury concentration in sediments not influenced by historic mining. The results also show that the mercury

concentrations in sediment in the lower segment of Jordan Creek are at least twice as high as those found in the upper segments of Jordan Creek. All the Jordan Creek sediment samples exceed the PEL sediment screening values for toxic effects in freshwater sediments. Two sediment samples from the downstream reaches of Jordan Creek exceed the SEL, indicating the representative material is considered highly contaminated and is anticipated to have significant adverse impacts on benthic resources.

In conclusion, the mercury sediment data for 2005 show high levels of mercury in the stream sediments, particularly in the upper reaches of Jordan Creek.

5. Pollutant Source Inventory

5.1. Point Sources

There is currently only one facility in the watershed that is permitted through EPA's National Pollutant Discharge Elimination System (NPDES): Kinross Delamar Mine. No unpermitted point sources of mercury are known to exist in the TMDL area. The most likely types of unpermitted point sources of mercury would be mine adits or tailings from past gold mining activities. There have been several studies in the Jordan Creek watershed looking for discrete or concentrated sources of mercury (Hill et al. 1973; Seronko 1995; USEPA 1998). These studies are described in more detail in section 5.2.2 below. The multiple studies of the historic mining area have not found any point sources of mercury.

Kinross Delamar mine is an inactive, open pit gold mine, located on a ridge between Jordan Creek and Louse Creek. The facility ceased mining operations in 1999 and is currently undergoing reclamation. This facility has two NPDES permits. Discharges directly to Jordan Creek are covered under the 2008 NPDES Stormwater Permit Multi-Sector General Permit. The facility's Notice of Intent application (Permit Number IDR050000, Tracking Number IDR05C177) classifies the operation as an active discharger and applies to approximately 2,000 acres within the Kinross Delamar Mine area of operation. Under the general permit, active operations are required to conduct chemical monitoring of stormwater and visual assessments of stormwater discharges. Chemical monitoring results are reported to EPA within 30 days of receiving complete laboratory results. Additional permit requirements address the general application of best management practices (BMPs) for controlling stormwater runoff and erosion. The general stormwater permit can be viewed at: http://yosemite.epa.gov/r10/water.nsf/Stormwater/industrial/

In 2004, Kinross Delamar initiated a voluntary monitoring plan to evaluate and to confirm the effectiveness of implemented BMPs. The Reclamation Performance Evaluation Monitoring Plan (KDMC 2004) is designed to assist Kinross Delamar personnel, along with federal and state agencies, to evaluate BMPs for managing stormwater runoff and erosion control efforts during reclamation of disturbed areas. The areas evaluated included reclaimed land, as outlined in the Kinross Delamar Mine Closure Plan (KDMC 2003), as well as areas of historic mining activity, road system, plant operation, mine/mill tailings, and water impoundments.

Data conducted between 2004 and 2008 showed 5 out of 113 "Reclamation Trigger" water quality samples were above the detection limit of 0.1μg/l for mercury. These detections occurred at four sample sites. Detection limits ranged from 0.1 μg/l to 0.3 μg/l (KDMC 2003, 2004, 2005b, 2006, 2007 and 2008). (The aquatic life criterion is 0.012 μg/l.) The exact location of the sample sites is not known because there is no map available or coordinates included in Kinross Delamar's reports.

A precise, current mercury load within the NPDES permitted area cannot be determined with available data. In addition, the municipal general stormwater permit (MSGP) does not specify a load limit for

mercury for the Kinross Delamar Mine or the reclamation activity associated with the closure of the facility.

The second permit is covered under the general permit for groundwater remediation. This is a discharge to unimpaired waters of Louse Creek, a tributary of Jordan Creek. The permit (number ID-G91-0007) was issued on October 13, 2010 and uses the 0.012 µg/l chronic aquatic life criterion for mercury to set mercury limits.

5.2. Nonpoint Sources

5.2.1. Historic Mining and Milling Activity

In 2005, IDEQ commissioned Jim Hyslip, a member of the Owyhee County Historic Society and part-time Silver City resident, to compile a narrative report on the historic use of mercury in the mining/milling operations of the Jordan Creek watershed. The completed report, *Mercury Use in Mining in the Area near Silver City, Idaho* (Hyslip 2006), provides a review of historic newspaper accounts, reference materials, and personal interviews of accounts of gold extraction, milling operations and production, and other related mining and milling activity in the Jordan Creek watershed.

A quote from the report illustrates the importance of mercury in the Jordan Creek watershed:

> *If gold and silver are the precious metals, then quicksilver—mercury is the essential metal. Without mercury, 19th century precious metal mining would not have been possible in most districts. Nearly all of the gold mining districts relied on amalgamation in arrastras, stamps, and pans for recovery of the values.*

Anecdotal accounts in Hyslip's report – e.g., "hundreds of pounds of mercury wasted/spilled daily", "using a ladle to dip quicksilver from the stream to sell back to the mills", "a bathtub full of mercury as a collection vessel", and "empty mercury flasks used as part of the Silver City Hotel's foundation" – indicate there was an abundance of mercury used in the area; and most of it, according to Hyslip, found its way to Jordan Creek.

Although the wide use of mercury in Jordan Creek is well documented, its fate is not well documented. One theory is that loss of mercury was just part of "the cost of doing business" in the Silver City area. The high yielding ore produced millions of dollars in gold and silver bullion for the owners. Extraction was the main priority of the mills, not the recovery of a $70-80 flask of mercury. Today, the main unanswered questions are the extent of recovery and reuse of mercury during active mining, methods of recovery (if any), disposal of "spent" mercury and the location of the tailings from mills that operated in the area.

5.2.2. Current Sources of Mercury Loadings

No known new "supplies" or sources of mercury have been identified in the Jordan Creek watershed with the exception of airborne deposition. This leaves legacy mining as the primary source of mercury. Visible particles of elemental mercury are still found in the stream sediments of Jordan Creek 80 years after it ceased to be intensively used in gold mining activities (Hill et al. 1973, Hyslip 2006). Elemental mercury is buried in deposits of sediments only to be exposed and moved during high flow events in Jordan Creek.

Elemental mercury may not be confined to the current stream channel but could also be deposited in the flood plain, buried deep in old meanders and spread out on irrigated land in the valleys. Water quality

data collected in 2005 show high concentrations of mercury in the Silver City area, indicating there is still a source, or sources, near major historic gold milling operations.

Sediment samples collected by EPA's START show a pattern where high mercury concentrations are located (USEPA 1998). The study focused a majority of its sampling effort in the Silver City area. Figure 7-1 shows high concentrations of mercury in sediments in that area, in the low gradient areas below the tailings above Louse Creek, and below Boulder Creek in the Pleasant Valley area.
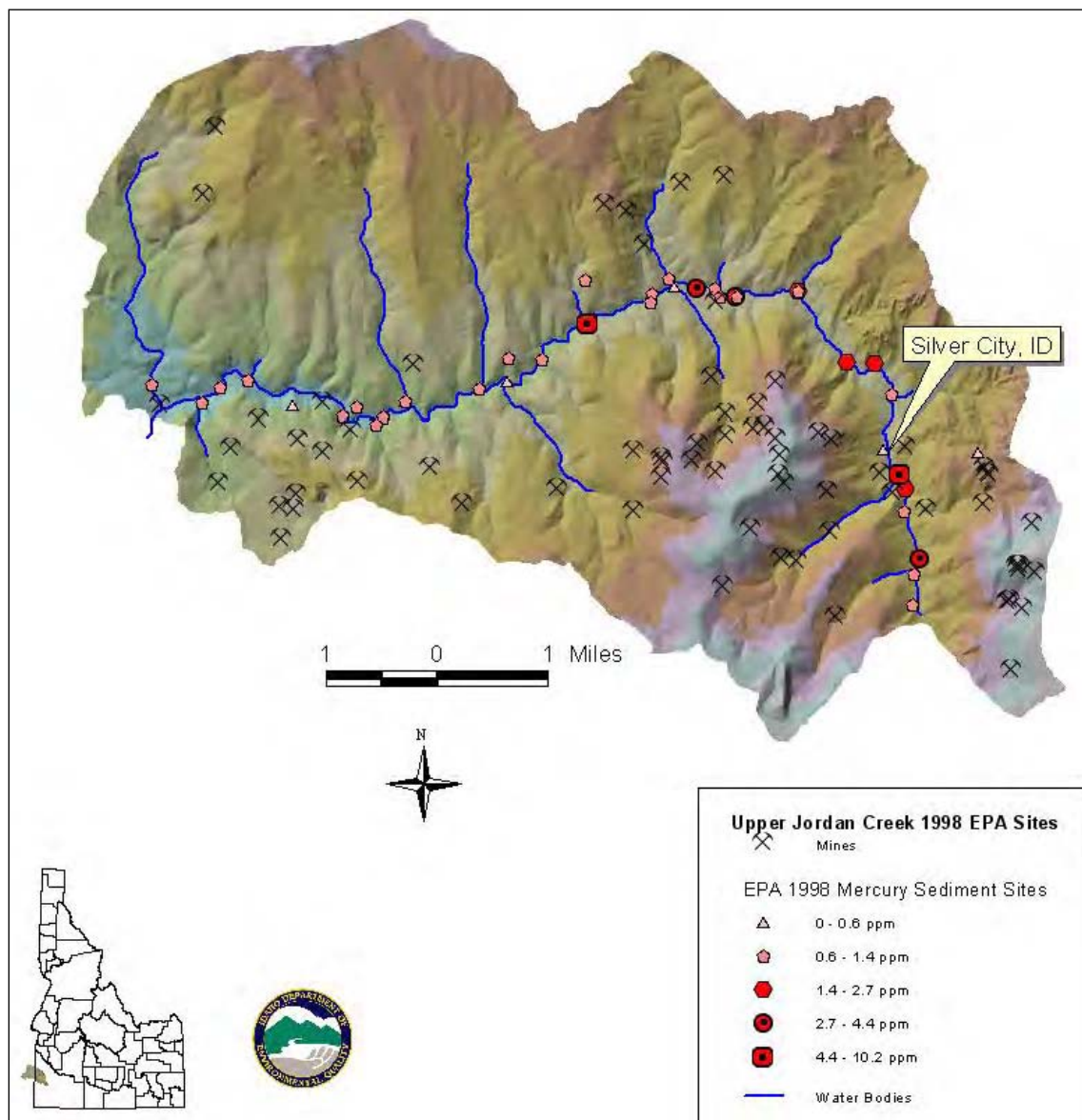
Figure 7-1. Location of EPA START sampling results and sampling sites in 1998.

5.2.3. Fate and Transport of Mercury in the Jordan Creek Watershed

Mercury from legacy mining in the upper reaches of Jordan Creek fuels methylmercury production in downstream waters of Jordan Creek and the Owyhee River. Mercury is highly persistent, and it bioaccumulates in the food web. Studies conducted on mercury contamination downstream of other

historic gold or mercury mining areas such as San Francisco Bay in central California (Guadalupe River TMDL Project), Walker Lake in eastern Nevada (Seiler et al. 2004), Cache Creek in Central California (Domagalski et al. 2004), and Steamboat Creek in eastern Nevada (Stamenkovic et al. 2003) all demonstrate that mercury contamination and elevated mercury in fish tissue are associated with redistributed mercury from mining sources. These studies underscore that the introduction of elemental mercury to the environment has had both far-reaching and long-lasting impacts.

Physical, chemical and biological conditions in an aquatic environment will cause elemental mercury to oxidize to ionic form, which is then more readily transported in solution. But even without such transformation, mercury does move; and in downstream low-gradient depositional areas, mercury accumulates as it attaches to particulates or precipitated salts. These low gradient areas also have physical conditions that enhance methylation of mercury. Mercury-attached particulates buried under deeper sediments outside of the stream channel may re-suspend years later during high flows as the stream meanders through the valley bottom. Thus, reduction of mercury loading in Jordan Creek will likely take decades if not centuries.

5.2.4. Background and Air Deposition Mercury Sources

Natural background mercury loading is associated with non-anthropogenic induced erosion from geological features and pre-industrial atmospheric deposition levels. This loading is difficult to ascertain because the global pool of atmospheric mercury has significantly increased over the last century by emissions from industrial and mining sources, and this has caused increased deposition of mercury onto the landscape (Schuster et al. 2002).

EPA modeled air deposition of mercury for the entire country in 2001 using the Regional Modeling System for Aerosols and Deposition (REMSAD) model (ICF International 2008). The estimated deposition to the Jordan Creek Subbasin is shown in Figure 7-2 and Table 7-1.
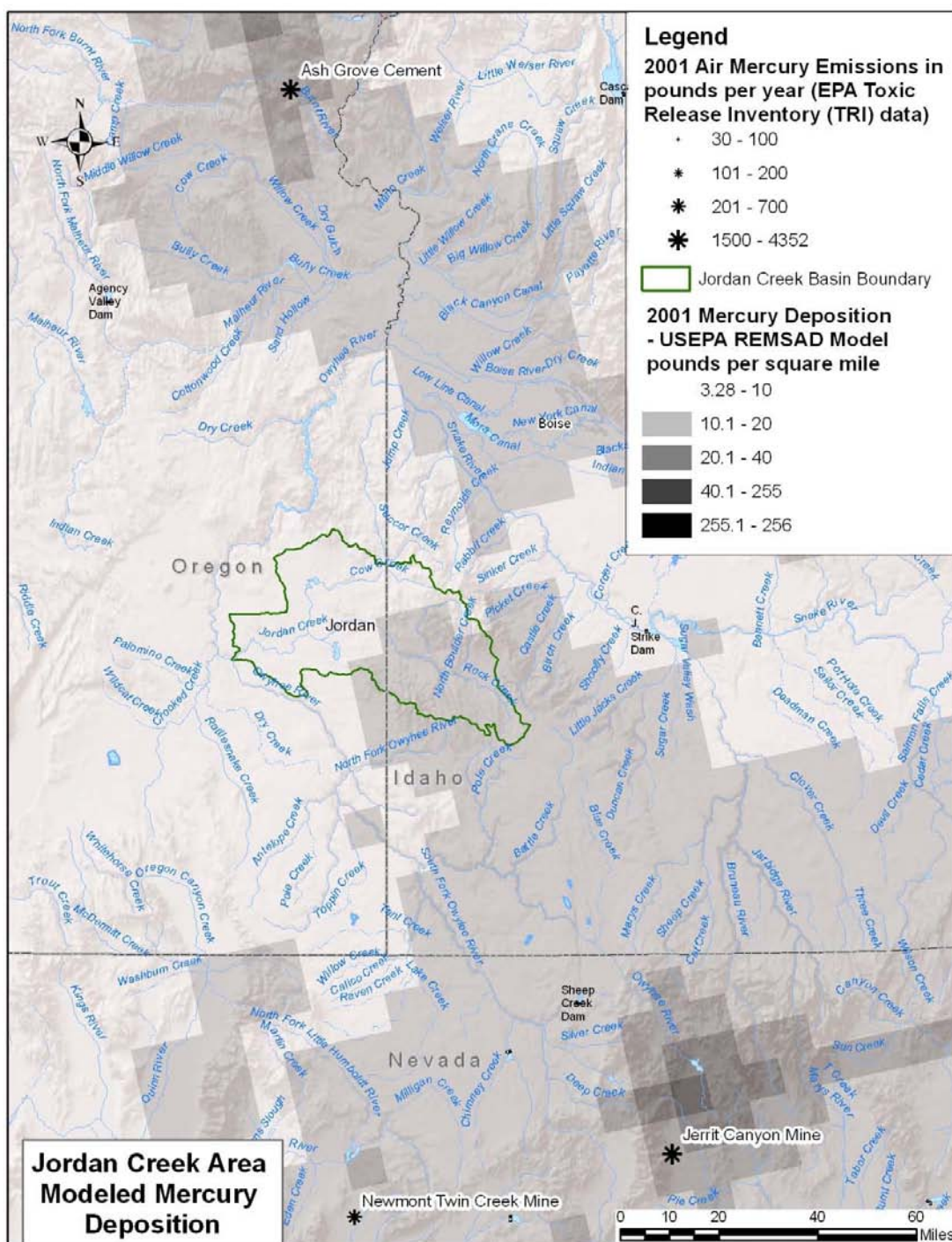
Figure 7-2. Mercury deposition estimated by REMSAD model for Jordan Creek Subbasin, 2001.

Table 7-1. Mercury Deposition Estimated by REMSAD Model for Jordan Creek Subbasin, 2001

Source	Location	Pounds	Percent
Background Global Mercury		61.77	85.8%
Ash Grove Cement	Oregon	3.90*	5.4%
Jerritt Canyon Mine	Nevada	3.25	4.5%
Other North American Sources		1.91	2.7%
Background Re-emission		0.71	1.0%
Florida Canyon Mine	Nevada	0.22	0.3%
Sierra Army Depot	California	0.22	0.3%
Total		71.98	

Note: The coordinates used in the REMSAD model for the Ash Grove Cement have been found to be located 23 kilometers northwest of the actual source of emissions. It is likely that a somewhat higher deposition from this facility has occurred in the Jordan Creek Watershed. (E-mail communication from Dwight Atkinson, EPA & Tom Meyers, ICF International, January 11, 2011)

The modeling indicates that over 85% of the mercury deposited on Jordan Creek Subbasin is from global sources that cannot be linked to a specific facility. Two regional sources made up almost 10% of the mercury deposited on the landscape—Jerritt Canyon Gold Mine in Nevada and Ash Grove Cement Plant in Oregon. Since this modeling was conducted, the State of Nevada has established and begun implementing regulations to control mercury emissions from gold mines. The State of Oregon negotiated an agreement with Ash Grove Cement to reduce their mercury emissions 85% by 2012. In addition to these control measures, EPA set national regulatory controls for mercury air emissions from cement plants and gold processing sources in 2010. It is estimated that these federal emissions standards will reduce mercury deposition from cement plants by 92% by 2013 and also reduce mercury emissions from gold ore processing facilities by 77% (USEPA 2010a and b).

Atmospheric sources contribute mercury to a water body through erosion and overland flow and direct deposition to the water surface. The reductions in air emissions that result from the regulatory processes will decrease the amount of mercury added to Jordan Creek. However, mercury that has already been deposited in elevated quantities in the subbasin will continue to erode into Jordan Creek, and global mercury sources outside U.S. regulatory controls will likely continue to deposit in the watershed for many years to come.

Because of the lack of information on the rate of terrestrial mercury transport into the stream network and the portions of this mercury that originate from natural versus anthropogenic sources, this TMDL assumes "background" includes both natural sources and air deposition sources of mercury. The combined geological and atmospheric mercury loading was evaluated by selecting waterbodies from un-mined watersheds that meet the human health and the aquatic life criteria. The 'background load' for these watersheds was used to represent the background load for the entire watershed. Data from these sites are shown in Table 7-2. Total mercury in the water column at these sites ranges between 0.00076 µg/l at East Creek and 0.0018 µg/l at Williams Creek and averages 0.00128 µg/l across all sites.

Table 7-2. Water Column Mercury Data from Areas of Jordan Creek Subbasin not affected by Historic Silver City Mining and Milling for August 2005 (IDEQ 2010)

Background Stations	Total Watershed Acres	Total Mercury (µg/l)	Measured Flow (cfs)
East Creek	2,844	0.00076	0.1
Williams Creek	5,819	0.0018	1.1
Flint Creek	9,495	0.00122	0.2
Louse Creek	13,715	0.0014	0.2
Boulder-Rock Creeks	18,260	0.00124	3.1
Average		0.00128	

5.3. Data Gaps

As discussed above, the sources of mercury in the watershed are not easily identified. It is likely that the stream substrate, including the current and historic flood plain, throughout the watershed contains elevated mercury. This section discusses the additional studies that are needed to evaluate sources of mercury pollution and factors affecting mercury concentrations in Jordan Creek.

Since the primary source of mercury is believed to be associated with legacy milling activity, additional monitoring is needed in these areas. Likely areas are historic stamp mill sites, arrastra mills, and placer operations in the Blue Gulch area.

Additionally, since the methods employed by mills to recover mercury are not known, sampling of the soils in upper reaches of the watershed would be helpful. If roasting/retorting methods were employed for the recovery of mercury, this may have provided a source of contamination to soils in the area. Aerial dispersal of mercury into the watershed is a possible source that has not received much attention, but should be considered for future evaluation.

Mapping and sampling of low gradient segments, old meanders, and irrigated areas of Jordan Creek would assist in identifying secondary sources of mercury in contaminated sediments and soils. Attempts to sample sediment profiles at defined depths to quantify mercury contamination and methylation potential is desirable. The potential for transport of mercury through pore water within the Jordan Creek substrate exists and should be studied. The lower trophic biota should be evaluated at the same time as they may prove to be a good marker of areas with elevated levels of mercury. Areas where stream bank erosion occurs should also be mapped and near stream soil/sediment samples collected to determine contribution from areas susceptible to erosion.

Tissue mercury concentrations in large fish in the lower Jordan Creek area could not be determined due to lack of large fish during the sampling event. Therefore, *Analysis of Total Mercury Concentrations in Fish Samples from Jordan Creek and Non-Jordan Creek Sites* (Dai and Ingham 2006) provided predicted concentrations. Actual data from fish tissue from lower Jordan Creek would be useful in confirming the estimates.

Water samples could be collected during low, medium and high discharge periods at multiple locations to determine mercury concentrations associated with sediment transport. This monitoring is difficult because clean hands techniques would be required, and discharge measurements and access may not be possible at all flows.

Additional monitoring is needed to assess seasonal variability in the Jordan Creek watershed. Establishing links between the transported organic and inorganic material and the mercury loads during various hydrologic events will improve the ability to identify primary sources, devise effective control measures, and establish more refined allocations.

6. Total Maximum Daily Load(s)

A TMDL identifies an upper limit on discharge of a pollutant from all sources to assure water quality standards are met. It further allocates this load capacity (LC) among the various sources of the pollutant. Pollutant sources fall into two broad classes: point sources, each of which receives a WLA, and nonpoint sources, each of which receives a load allocation (LA). Natural background, when present, is considered part of the LA, but is often treated separately because it represents a part of the load not subject to control. Because of uncertainties regarding quantification of loads and the relation of specific loads to attainment of water quality standards, the rules regarding TMDLs (water quality planning and management, 40 CFR Part 130) require that a margin of safety (MOS) be a part of the TMDL.

This can be summarized symbolically as the equation:

LC = MOS + Natural Background + LA + WLA = TMDL.

The equation is written in this order because it represents the logical order in which a loading analysis is conducted. First, the LC is determined. Then the LC is broken down into its components: the necessary MOS is determined and subtracted; then natural background, if relevant, is quantified and subtracted; and then the remainder is allocated among pollutant sources. When the breakdown and allocation are completed, the result is a TMDL, which must equal the LC. The LC must be based on critical conditions—the conditions when water quality standards are most likely to be violated. If protective under critical conditions, a TMDL will be more than protective under other conditions. Because both LC and pollutant source loads vary, and not necessarily in concert, determination of critical conditions can be complicated.

A load is fundamentally a quantity of a pollutant discharged over some period of time and is the product of concentration and flow. Due to the diverse nature of various pollutants and the difficulty of strictly dealing with loads, the federal rules allow for "other appropriate measures" to be used when necessary. These "other appropriate measures" must still be quantifiable and relate to water quality standards, but they allow flexibility to deal with pollutant loading in more practical and tangible ways. The rules also recognize the particular difficulty of quantifying nonpoint loads and allow "gross allotment" as a LA where available data or appropriate predictive techniques limit more accurate estimates. Loadings should be described as daily loads; however, for some pollutants such as mercury it may also be appropriate to express as seasonal or monthly loads.

6.1. Seasonal Variation, Critical Conditions and Uncertainty

The TMDL establishes the LC and allocates loads based on the aquatic life criterion, fish tissue criterion, and the available USGS flow data. The percent load reduction is based on the data collected in the low-flow period.

The analysis for the TMDL contains numerous sources of uncertainty, and load allocations must be proposed as best estimate "gross allotments" in keeping with the TMDL regulation at 40 CFR 130.2(g). Key areas of uncertainty have been highlighted in Section 7 (Pollutant Source Inventory) and are

summarized below. The need for additional data collection, analysis, and modeling to reduce these areas of uncertainty are outlined in Section **7.3** (Data Gaps).

The sources of uncertainty are:
1) The lack of data on mercury concentrations in the stream during conditions of high flow and from more than one season or year.
2) Very little information on fate and transport of mercury in the Jordan Creek system.
3) A lack of information on the food web in Jordan Creek
4) Insufficient information on rates of mercury methylation in Jordan Creek.

Mercury concentrations during high-flow conditions and flow data: There are only six locations in Jordan Creek and four in tributary streams that have water column mercury concentration data assessed with sufficient precision to determine whether the aquatic life criterion are being met. All of this information was collected during low-water conditions in August of 2005. There is no data of equal precision from other seasons and flow conditions.

The TMDL assumes that the mercury concentrations from August 2005 are representative of all flow conditions. It is likely that with greater stream velocity at high flows, more mercury laden sediments might be transported in the stream than during low-flow conditions. It is uncertain in a stream as flashy as Jordan Creek how the volume of water would dilute this load.

Calculating the seasonal changes in the concentration, loading and transport of mercury is not possible with the available data. Because flow and loading are also difficult to establish in this watershed due to the very limited usable sampling data, the allocations in this TMDL are based on monthly average flows, including periods of low flow during the summer and early fall. But LC and allocations are higher at other times of the year, when average flows are higher. With the limited available data it is not possible to determine whether this method over estimates or underestimates the concentrations of mercury at higher flows. High flows may transport a disproportionately greater concentration of mercury than lower flows or they may dilute it. Because of this uncertainty an explicit margin of safety of 15% has been added to the TMDL. As additional data regarding flow and loading become available to identify more critical periods of flow or loading, the LC and allocations can be adjusted.

Fate and Transport: Mercury is volatile and a certain quantity can be lost to the atmosphere during stream transport. It can also bind to particles and settle into the sediments, sometimes remaining buried where it no longer poses a risk for uptake into the food chain. There is no data on mercury transport within the Jordan Creek system to allow for calculation of this type of loss, and none was assumed in the TMDL load analysis. This is a conservative assumption and is part of the implicit margin of safety for the TMDL.

Food Web: There is some data on the type of fish species present in Jordan Creek. However, there is no specific information on what the fish eat or on concentrations of mercury in macroinvertebrates and phytoplankton in reaches of Jordan Creek. Food web dynamics are a very important factor in determining the amount of mercury in fish. The TMDL assumed a linear relationship between the concentration of mercury in the water column and the amount of mercury in fish tissue that greatly simplifies the reality of mercury uptake in aquatic species. It is not possible to determine whether this is a conservative assumption, but because the load capacity and allocations were determined based on both water column and fish tissue data from locations throughout the watershed, it is likely that the uncertainty about food web dynamics effects is relatively low. Al 2.5% explicit margin of safety has been added to the TMDL to offset this uncertainty in addition to the 15% margin of safety mentioned above.

Methylation Rates: Though concentrations of methylmercury were quantified at the same sites where mercury water column data were collected, there are still insufficient data on mercury methylation rates in Jordan Creek. Methylmercury is the toxic form of mercury that is primarily found in fish and other aquatic organisms and to which the human health, fish tissue criteria apply. The TMDL load analysis assumed a linear relationship between the levels of mercury in fish tissue and the levels of total mercury in the stream. The concentrations of mercury in fish only indirectly correspond to total mercury in the water column.

Similar to the assumptions made for mercury in the food web, it is not possible to determine whether this TMDL assumption is conservative. The load capacity and allocations were determined based on both water column and fish tissue data from locations throughout the watershed during the low water season, which is generally the period of highest methylation in freshwater systems (citation). It is likely that the uncertainty about rates of mercury methylation has a relatively low impact on the determination of needed mercury reductions in the watershed. An additional 2.5% margin of safety has been added to the TMDL to offset uncertainty about methylation rates, resulting in a 20% margin of safety for the TMDL.

Despite these sources of uncertainty in the estimation of the mercury TMDL for Jordan Creek, it is evident, however, that existing loads of mercury are too high to support designated uses, as shown by the tissue concentrations observed in fish and water column mercury data.

Quantitative estimates are possible at this time for few of the sources of uncertainty in the TMDL. It is also not appropriate to assume that all the sources of uncertainty are additive, since some sources will have positive or negative correlations with other sources. A full, quantitative analysis of uncertainty in the TMDL has not yet been feasible, but it might be appropriate as additional data are collected. However, there is a high probability that the true LC of Jordan Creek lies within plus or minus 20 percent of the best estimates presented below.

The TMDL regulation requires that estimates of LC be made even where there is uncertainty in load estimates and only "gross allotments" are possible for nonpoint loads. This report provides a best estimate from currently available data of the LC for mercury and the needed load reductions for Jordan Creek. However, the uncertainty in these estimates is high. This uncertainty is addressed in part through use of a MOS (Section 6.3). The level of uncertainty, however, suggests the need for ongoing, adaptive management to meet water quality standards in Jordan Creek. In particular, a monitoring program must be part of any implementation plan. Such a monitoring program will allow tracking of progress in attaining acceptable fish tissue and water column concentrations in response to management actions. It would also provide the basis for potential revision of the estimated load allocations consistent with attaining standards in Jordan Creek.

The uncertainty in the estimation of LC and the TMDL should be reduced directly through collection of additional data to better characterize mercury fate and transport, methylation rates and food web dynamics and data on mercury concentrations during high-water conditions and other seasonal data. General monitoring recommendations appropriate to assess trends and refine estimates of loading and LC include the following:

- Continue fish monitoring in Jordan Creek using a standardized sample collection protocol.

- Continue mercury monitoring at established sample sites and gather data for varying flow conditions.

- Study food web and mercury methylation rates for two locations in Jordan Creek to assess variation between the upper higher velocity reaches and the slower moving downstream reaches.

6.2. Margin of Safety

All TMDLs are required to include a MOS to account for uncertainty in the understanding of the relationship between pollutant discharges and water quality impacts. The MOS may be provided explicitly through an unallocated reserve or implicitly through use of adequately conservative assumptions in the analysis.

The Jordan Creek mercury TMDL incorporates both an explicit margin of safety as an unallocated reserve equal to 20 percent of the estimated LC and an implicit MOS based on conservative assumptions in the TMDL analysis. As described in Section 6.2, the margin of uncertainty about the estimated LC is believed to be approximately 20 percent for Jordan Creek.

The conservative assumptions that form the implicit MOS include:

- All mercury in fish tissue is assumed to be methylmercury. Studies have generally placed the amount of methylmercury in fish at greater than 95 percent of the total mercury in the fish (USEPA 1997).

- Mercury is assumed to be conserved in the system, when in fact a percentage will be lost to evasion and burial in sediments.

- Air deposition of mercury in the watershed is assumed to equal 2002 levels. Since that time the State of Nevada has instituted regulations for reduction of mercury emission from gold mining operations in northern Nevada that the model showed as contributing to deposition in the Jordan Creek watershed. Significant reductions in mercury emissions have already been documented (Elges and Bamford 2010). In addition the State of Oregon has negotiated a Mutual Agreement and Order (MAO) with a schedule for reduction of mercury emissions from the Ash Grove Cement Plant, which also is a source of mercury deposition on the Jordan Creek watershed (Oregon DEQ 2008).

Uncertainty in the analysis for Jordan Creek is caused in large part by uncertainty in estimates mercury water column concentrations during high flow conditions. For the downstream TMDL target, lack of information on the methylation mechanism and rates for these reaches and also food web dynamics relationship between total mercury concentrations in the water column and methymercury concentrations in fish tissue. This uncertainty can only be addressed through the collection of mercury concentration data representing a range of flow conditions in the stream and further information on mercury methylation and food web uptake information for reaches of Jordan Creek.

In sum, the TMDL incorporates a MOS that is believed to account for uncertainty in the understanding of the relationship between pollutant discharges and water quality impacts. It is not, however, possible at this time to precisely estimate the magnitude of uncertainty in the estimation of stream loading capacities.

6.3. In-stream Water Quality Targets

This TMDL assumes that reduction in the total mercury load will produce a commensurate reduction in fish tissue mercury and water column mercury. Consequently, reduction in the total mercury load at any given time is expected to equal the reduction required in fish tissue mercury levels to achieve the fish tissue criterion and the reduction required in water column concentrations to meet the chronic criterion for protection of aquatic life. Based on this assumption, comparing the necessary reductions in current fish tissue concentrations and water column concentrations to meet the respective criterion determines the more restrictive of the two criteria. The more restrictive criterion drives the selection of mercury load reductions that will ensure both criteria are met and thus the protection of both human health and aquatic life.

Load reductions needed to achieve the aquatic life and fish tissue criteria in Jordan Creek were calculated for six locations based on IDEQ's 2005 study. This is the most recent mercury study in Jordan Creek, and it is the only study that used detection limits that are lower than the chronic aquatic life mercury criterion and had paired sampling of fish, water and sediment for mercury. The steps in calculating the most restrictive percent reduction in mercury are:

- Calculate necessary reduction in observed fish tissue concentrations to meet fish tissue target of 0.24 mg/kg (the 0.3 mg/kg methylmercury fish tissue criterion for protection of human health minus a 20% MOS to account for uncertainty)

- Calculate necessary reduction in observed water column concentrations to meet aquatic life target of 0.010 µg/l (the 0.012 µg/l total mercury water criterion for protection of aquatic life minus a 20% MOS to account for uncertainty)

- Compare the tissue reduction and water column reduction, and select the higher of the two as the final reduction needed to meet water quality criteria.

In Table 8-1, sites JC-2005-02 through JC-2005-11 represent the upper portion of the watershed most impacted by legacy mining. Site JC-2005-01 represents the downstream portion of the watershed, as measured near the Idaho – Oregon stateline. The table lists trophic level weighted average mercury tissue concentrations and the resulting fish tissue reduction required to reach the target fish tissue mercury level of 0.24 mg/kg at all six sites sampled. It also lists the mercury water column concentrations and the resulting concentration reduction required to meet the aquatic life target of 0.010 µg/l. The last two columns of the table show the higher of the two reductions for each site, needed to achieve both criteria, and the resulting water quality concentration given that reduction. In addition to supporting the analysis to calculate the water quality targets, these percent load reductions provide information on the relative magnitude of load reduction needed from the historic mines and surrounding areas.

Table 8-1. Reductions Calculated for Tissue and Water Column Concentrations to Meet Respective Targets

Station	Site ID	Weighted avg. fish tissue conc. (mg/kg)	Human health target (mg/kg)	Percent reduction to meet human health target	Current total Hg water column conc. (µg/l)	Aquatic life target (µg/l)	Percent reduction to meet aquatic life target	Maximum reduction	Total Hg water column conc. after reductions (µg/l)
Jordan Near Stateline	JC-2005-01	0.750[a]	0.24	68%	0.0199	0.01	50%	68%	0.006
Jordan Below Boulder Creek	JC-2005-02	0.670[a]	0.24	64%	0.0314	0.01	68%	68%	0.010
Jordan below Placer Tailings	JC-2005-08	0.405	0.24	41%	0.0134	0.01	25%	41%	0.008
Jordan Below Delamar Mine	JC-2005-09	0.473	0.24	49%	0.0353	0.01	72%	72%	0.010
Jordan below Blue Gulch	JC-2005-10	0.534	0.24	55%	0.0579	0.01	83%	83%	0.010
Jordan below Silver City	JC-2005-11	0.588	0.24	59%	0.0927	0.01	89%	89%	0.010

a. Estimated mercury tissue concentration

Within the upper watershed, reductions to achieve the aquatic life criterion are more restrictive than those needed to achieve the fish tissue criterion. Therefore, the target of 0.010 µg/l represents attainment of both the human health criterion and aquatic life criterion in the upper watershed.

Within the lower portion of the watershed, reductions to achieve the fish tissue criterion are more restrictive than those to achieve the water column criterion. Until more representative data are available, conservative assumptions have been used to set the percent reduction of mercury concentration and loading at 68% in the lower watershed to achieve the fish tissue criterion in the vicinity of the state line (based on data at JC-2005-01, Jordan Creek near Stateline). Since the current concentration measured near the state line is 0.0199 µg/l, a 68% reduction results in an "adjusted" target concentration of 0.006 µg/l total mercury (Table 8-1). This concentration represents attainment of both the water column and fish tissue criteria.

Based on the preceding analysis, the final water quality targets for the Jordan Creek mercury TMDL are summarized in Table 8-2.

Table 8-2. Water Quality Targets for Impaired Segments in Jordan Creek

Location	Corresponding Impaired Segments (listed in upstream to downstream order)	Water Quality Target
Upper Jordan Creek watershed	• ID17050108SW004_02 (1st and 2nd order Jordan Creek tributaries upstream of Williams Creek including Jordan Creek upstream of Jacobs Gulch) • ID17050108SW004_03 (Jordan Creek between Louse Creek and Jacobs Gulch - 3rd order) • ID17050108SW004_04 (Jordan Creek - Louse Creek to Williams Creek)	0.010 µg/l
Lower Jordan Creek watershed	• ID17050108SW004_05 (Jordan Creek between Big Boulder Creek and Williams Creek - 5th order) • ID17050108SW001_05 (Jordan Creek - Williams Creek to Oregon Border)	0.006 µg/l

6.4. Calculation of Load Capacity

Using the water quality targets discussed in Section 8.1, a LC was calculated for two sites—one near the Idaho-Oregon state line and one below the historic locale of Delamar, which represent the lower and upper watershed, respectively. Both locations have historic USGS gage sites that provide average flow data necessary for calculating mercury loads. (Section 3.3.1 contains more information on these gage sites.) The site below Delamar marks the end of the reach most affected by legacy mining. The watershed for this location is shown in Figure 7-1, which also shows the historic mines located in the area. The lower site near the state line represents allocations that apply at the border with Oregon and for impaired segments in the lower watershed. The locations of the sample sites and the USGS gages are shown in Figure 8-1.
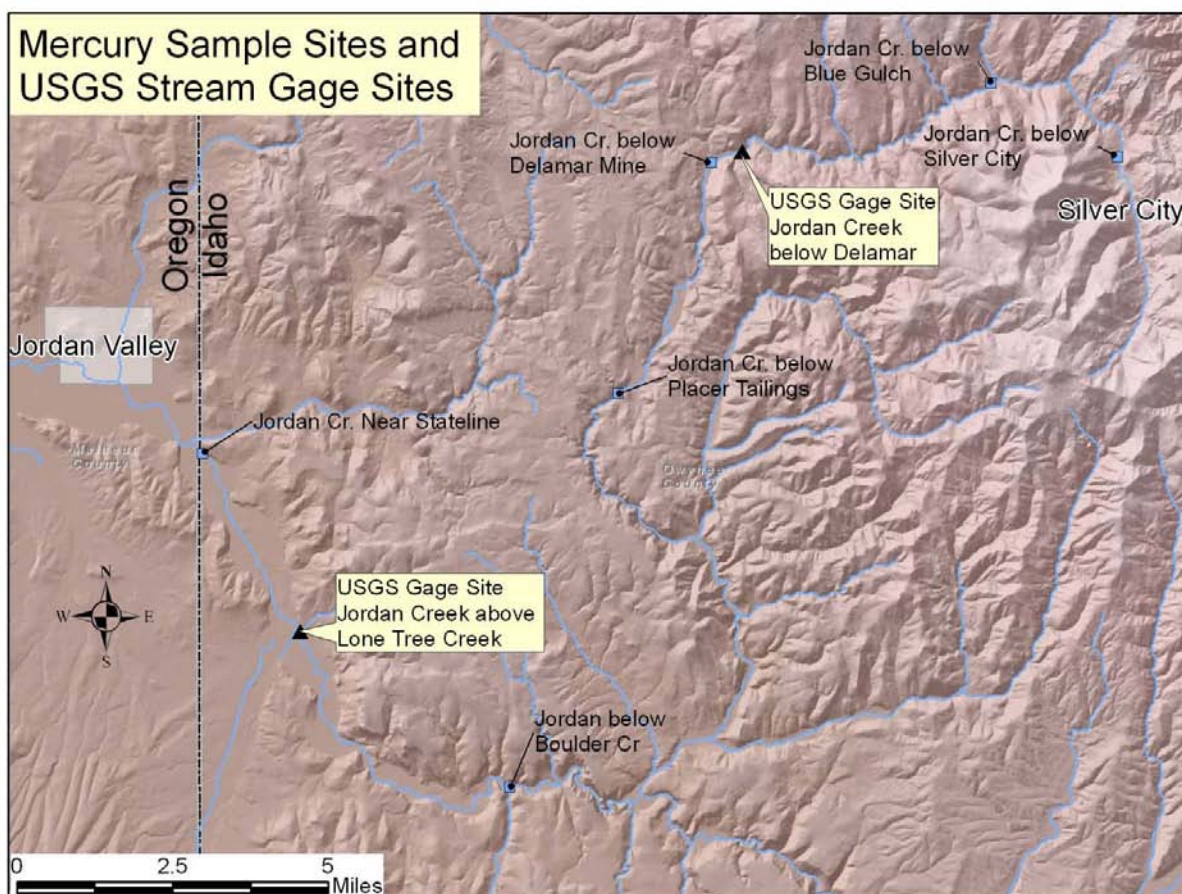
Figure 8-1. Location of mercury sampling sites and USGS stream gages used in calculating the LC for Jordan Creek.

The goal of the TMDL is to protect aquatic organisms and human health by reductions in mercury levels sufficient to attain both the aquatic life and fish tissue criteria at all times and under all flow conditions. To achieve this goal, the LCs for the upstream and downstream sites were calculated by multiplying the respective water quality target by average monthly flows for that site. For the upper watershed, monthly LCs were calculated using the water quality target of 0.010 µg/l (Table 8-1) and flows measured at the USGS gage site below Delamar. Monthly LCs for the upper watershed are listed in the third column of Table 8-3. These allocations correspond to the following impaired segments (upstream to downstream order):

- ID17050108SW004_02 (1st and 2nd order Jordan Creek tributaries upstream of Williams Creek including Jordan Creek upstream of Jacobs Gulch)

- ID17050108SW004_03 (Jordan Creek between Louse Creek and Jacobs Gulch - 3rd order)

- ID17050108SW004_04 (Jordan Creek - Louse Creek to Williams Creek)

For the downstream portion of the watershed, monthly LCs were calculated using the water quality target of 0.006 µg/l (Table 8-1) and flows measured at the USGS gage below Lone Pine Creek near the Idaho-Oregon stateline. Resulting monthly LCs are also listed in the third column of Table 8-3. These allocations correspond to the following impaired segments:

- ID17050108SW004_05 (Jordan Creek between Big Boulder Creek and Williams Creek - 5th order)

- ID17050108SW001_05 (Jordan Creek - Williams Creek to Oregon Border)

Table 8-3 summarizes the LCs for each station by month, as well as the corresponding LAs and WLAs for the watershed. The following sections discuss how these LAs and WLAs were calculated.

Table 8-3. Load Capacity and Daily Load and Wasteload Allocations for Jordan Creek

Month	Average Flow (cfs)	Load Capacity (mg/day)	Load Allocation - Background (mg/day)	Load Allocation - Legacy Mining (mg/day)	Wasteload Allocations - Kinross - Delamar Mine	
					MSGP Stormwater (mg/day)[1]	Groundwater Remediation (mg/day)
Jordan Creek Below Delamar[2]						
January	14.0	343	44	295	3.19	-
February	38.0	930	119	802	8.67	-
March	55.0	1,346	172	1,161	12.55	-
April	107.0	2,618	335	2,258	24.41	-
May	164.0	4,012	514	3,461	37.41	-
June	46.0	1,125	144	971	10.49	-
July	5.9	144	18	125	1.35	-
August	0.8	20	3	18	0.19	-
September	0.5	12	2	11	0.12	-
October	1.1	27	3	23	0.25	-
November	2.5	61	8	53	0.57	-
December	15.0	367	47	317	3.42	-
Jordan Creek near the state line[3]						
January	135.0	1,982	423	1,535	6.39	18
February	184.0	2,701	576	2,068	17.34	40
March	307.0	4,507	961	3,480	25.09	40
April	736.0	10,804	2,305	8,260	48.81	191
May	585.0	8,587	1,832	6,549	74.82	132
June	185.0	2,716	579	2,098	20.99	18
July	26.0	382	81	284	2.69	13
August	5.1	75	16	53	0.38	6
September	4.7	69	15	48	0.23	6
October	11.0	161	34	121	0.50	6
November	26.0	382	81	281	1.14	18
December	77.0	1,130	241	865	6.84	18

1. The Kinross Delamar Mine daily WLA for stormwater, which is calculated for average annual flow in Section 8.6, is interpolated to average daily flow by month using the following formula: monthly WLA = average annual WLA × (average monthly flow/average annual flow). In addition, half of the Kinross Delamar stormwater WLA is assumed to discharge in the upstream segment. The entire WLA is accounted for in the lower segment.
2. Allocations at this site apply to the following impaired segments:
   - ID17050108SW004_02 (1st and 2nd order Jordan Creek tributaries upstream of Williams Creek including Jordan Creek upstream of Jacobs Gulch)
   - ID17050108SW004_03 (Jordan Creek between Louse Creek and Jacobs Gulch - 3rd order)
   - ID17050108SW004_04 (Jordan Creek - Louse Creek to Williams Creek)
3. Allocations at this site apply to the following impaired segments:
   - ID17050108SW004_05 (Jordan Creek between Big Boulder Creek and Williams Creek - 5th order)
   - ID17050108SW001_05 (Jordan Creek - Williams Creek to Oregon Border)

6.5. Load Allocations

Separate LAs are calculated for background loading, which includes the load of mercury from atmospheric deposition, and for the historic mining and milling legacy loading originating in the upper watershed. These allocations are listed in the fourth and fifth columns of Table 8-3 and are discussed in this section.

Background and air deposition loading is discussed in Section 7.2.4. The background load, which encompasses atmospheric deposition as well as natural geologic sources is derived using the 0.00128 µg/l concentration that is the average of the reference site concentrations, as shown in Table 7-2 and discussed in Section 7.2.4. This background concentration is multiplied by monthly average flows to derive monthly background allocations in the fourth column of Table 8-3.

In the upper watershed, the only known sources are natural background, atmospheric deposition, and historic legacy mining. The historic mines and mill site sources of mercury are all located in the watershed above Delamar. Although there are other historic mine sites in Flint Creek and Williams Creek, investigations at these sites, and in waters downstream of them, do not shown elevated mercury levels (IDEQ 2009, IDEQ 2002, USEPA 1998, Seronko 1995, Bennett et al. 1998, Hill et al. 1973). To assign a LA to the historic mining and milling sites, the WLA assigned to the Kinross Delamar stormwater source for this portion of the watershed (discussed in Section 8.6) and the background LA are subtracted from the LC. The remaining amount is assigned as a LA to historic mining and milling sites and appears in the fifth column of Table 8-3. This load allocation represents a 90% reduction for legacy mining sources of mercury.

For the lower watershed, the LA was derived by subtracting the WLA assigned to Kinross Delamar mine stormwater and remediation discharges and the LA to background sources in the watershed from the LC. The remaining amount is the LA to historic mining within Jordan Creek and appears in the fifth and sixth column of Table 8-3.

6.6. Wasteload Allocations

The Kinross Delamar Mine site contains the only point sources of mercury in the Jordan Creek watershed. Stormwater from the mine are discharged to Jordan Creek, and groundwater remediation fluids from the mine are discharged into Louse Creek. The specifics about the Kinross Delamar Mine operation are discussed in Section 7.1. Calculation of the WLA for the Kinross Delamar Mine stormwater discharge is described in Section 8.6.1. Calculation of the WLA to the Kinross Delamar mine groundwater remediation discharge is described in Section 8.6.2.

6.6.1. Wasteload Allocation for Stormwater

The Simple Method (Schueler 1987) was used to estimate the pollutant loads carried by Kinross Delamar mine stormwater (relying on the chronic aquatic life criteria for total mercury (0.012 µg/l) in the site's stormwater). This unit area model estimates loads of chemical constituents as a product of annual runoff volume and pollutant concentration, according to the formula:

$$L = 0.226 * R * C * A$$

$$L = 0.226*2.538 \text{ inches}*0.000012 \text{ mg/l}*2,000 \text{ acres} = 0.0138 \text{ lbs per year}$$

Where:

L = Annual load (lbs)

R = Annual runoff (inches) – calculated below

C = Pollutant concentration (mg/l) – 0.000012 mg/l mercury
A = Area (acres) – 2,000
0.226 = Unit conversion factor

Annual runoff (R) is estimated as the product of rainfall, fraction of events that yield runoff, and a runoff coefficient:

$$R = P * Pj * Rv$$
$$R = 20 \text{ inches} * 0.9 * (0.05 + (0.91 * 0.1)) = 2.538$$

Where:
R = Annual runoff (inches)
P = Annual rainfall (inches) = 20 inches on average
Pj = Fraction of annual rainfall events that produce runoff (usually 0.9)
Rv = Runoff coefficient
Rv = 0.05+(0.91*Impervious Fraction (0.1))

The area of the mine is approximately 2,000 acres.

Annual runoff was based on Figure 2 in the IDEQ Jordan Creek TMDL, reproduced as Figure 1-3 in this TMDL document. The average annual precipitation for the Kinross Delamar Mine is estimated to be 20 inches.

In the absence of other information, the fraction of annual rainfall events that produce runoff (Pj) is usually assumed to be 0.9. This value has a strong effect on the results and is a potential source of bias in the load estimates.

The equation for Rv is the best fit line for the relationship between the storm runoff coefficient and watershed imperviousness (Schueler 1987). An impervious fraction of 10% was used to calculate Rv. This value was estimated based on aerial photographs of the mining site.

Results of the stormwater load calculations are shown in Table 8-4.

Table 8-4. Wasteload Allocation for Kinross Delamar Mine MSGP Stormwater

	Annual Load	Daily Load
WLA in milligrams	6,244.20	17.11
WLA in pounds	0.01377	0.00004

The advantage of using the Simple Method is that it requires a modest amount of information and is considered to provide reasonable estimates of pollutant export from urban areas (www.stormwatercenter.net). It is important, however, not to over emphasize the precision of the results obtained.

The Kinross Delamar Mine stormwater permit covers discharges to Jordan Creek and its tributaries in the vicinity of Delamar, and discharges to streams in the Flint Creek tributary watershed of Jordan Creek. Since stormwater from the facility flows into both the upper and lower segments of Jordan Creek, half of the stormwater allocation has been assumed to discharge in the upstream segment. The entire stormwater allocation is accounted for in the lower segment. In addition, the stormwater WLA has been divided proportionally across the year in Table 8-5 based on the ratio of the monthly stream flow to the average annual flow, to reflect the assumption that stormwater discharge is expected to be proportional to stream flow. The monthly WLAs were calculated using the following formula:

monthly WLA = average annual WLA × (average monthly flow/average annual flow)

Table 8-5. Kinross Delamar Mine Reclamation Stormwater Permit WLAs

Month	Average Flow (cfs)	Jordan Creek below Delamar - Stormwater WLA (mg/day)	Average Flow (cfs)	Jordan Creek near state line - Stormwater WLA (mg/day)
January	14.0	3.19	135.0	6.39
February	38.0	8.67	184.0	17.34
March	55.0	12.55	307.0	25.09
April	107.0	24.41	736.0	48.81
May	164.0	37.41	585.0	74.82
June	46.0	10.49	185.0	20.99
July	5.9	1.35	26.0	2.69
August	0.8	0.19	5.1	0.38
September	0.5	0.12	4.7	0.23
October	1.1	0.25	11.0	0.50
November	2.5	0.57	26.0	1.14
December	15.0	3.42	77.0	6.84

6.6.2. Wasteload Allocation Groundwater Remediation Discharge

Effluent discharged from Kinross Delamar's groundwater remediation process flows into unimpaired waters of Louse Creek, which is a tributary of Jordan Creek downstream of the upper gage below Delamar. The NPDES permit limits are based on achieving the aquatic life criterion of 0.012 µg/l in discharge water, given a 5:1 dilution in the mixing zone in Louse Creek. This point source is given a WLA equivalent to current permit limits. Average daily loads are calculated for each month of the year in Table 8-6. 40 CFR 122.44 (d)(1)(vii)(B) requires NPDES permit limits to be consistent with the assumptions and requirements of any available wasteload allocation. While this numeric mass based WLA appears in Table 8-3, there is no intent that this mass-based allocation replace, be added to, or otherwise change the concentration-based limit in the groundwater remediation permit. The current permit limit and the mass-based allocation are intended to be equivalent, and the mass-based limit is shown in Table 8-3 to illustrate how allocations to all known mercury sources achieve the LC established for mercury at the Idaho-Oregon state line.

Table 8-6. Kinross Delamar Groundwater Remediation Permit Wasteload Allocation

Month	Design Flow (cfs)[1]	Wasteload Allocation (mg/day)
January	0.12	18
February	0.27	40
March	0.27	40
April	1.3	191
May	0.9	132
June	0.12	18
July	0.09	13
August	0.04	6
September	0.04	6
October	0.04	6
November	0.12	18

Month	Design Flow (cfs)[1]	Wasteload Allocation (mg/day)
December	0.12	18

1. Flow data from KDMC (2010); data reproduced in Appendix A of this document.

6.7. *Reasonable Assurance*

When a TMDL is developed for waters impaired by both point and nonpoint sources of pollution, and the waste load allocation is based on an assumption that nonpoint source load reductions will occur, the TMDL should provide reasonable assurances that nonpoint source pollution control measures will achieve expected pollutant load reductions. *Guidance for Water Quality-based Decisions: The TMDL Process* (EPA 1991). EPA's 1991 guidance adds that where load reductions are allocated to nonpoint sources in lieu of additional load reductions allocated to point sources, then a TMDL must provide specific assurances that the nonpoint source reductions will in fact occur. Where there is no reasonable assurance that nonpoint source reductions will be achieved, the entire load reduction must be assigned to point sources.

Mercury sources in Jordan Creek are diffuse, ubiquitous, and not well understood. There is substantial uncertainty about the sources and pathways of mercury pollution in the watershed. The primary source of mercury is historic gold and silver mining activity in headwaters areas. Those activities contaminated stream sediments in Jordan Creek from its headwaters to the Oregon state border. Other mercury sources include atmospheric deposition and natural background loading, as well as two point sources. The limited data available on mercury contamination – i.e., in-stream samples taken in a single low water season – presents a significant challenge in understanding the source, transport, and fate of mercury in the Jordan Creek system. Despite the paucity of data on mercury contamination, the goal of this TMDL is to achieve the aquatic life and fish tissue criteria at all times and under all flow conditions.

The proposed TMDL establishes a LC and allocates loads based on an aquatic life criterion, fish tissue criterion, and available USGS flow data. Load reductions are based on data collected during a low-flow period. The load reductions also include a 20% margin of safety because of our limited data on mercury concentrations during medium and high flow conditions, and a minimal understanding of fate and transport of mercury, food web dynamics and methylation of mercury in Jordan Creek.

The LCs under this TMDL, as discussed in Section 6.4, were calculated by multiplying the water quality target by average monthly flows for that site: i.e., for the upper watershed, monthly LCs were calculated using the water quality target of 0.010 µg/l and flows measured at the USGS gage site below Delamar; and for downstream portion of the watershed, monthly LCs were calculated using the water quality target of 0.006 µg/l and flows measured at the USGS gage below Lone Pine Creek near the Idaho-Oregon stateline. LAs were then assigned to nonpoint sources by subtracting both background loading (i.e., natural loading and atmospheric deposition) and WLA from the LC for the watershed. The LA to nonpoint sources represents 77% of the assimilative capacity for mercury in the Jordan Creek watershed, background loading represent 21% and wasteload allocation to point sources represent 2%.

Jordan Creek is the only location in Idaho, and one of only a handful of sites in the United States, where mercury pollution in the water column and sediments is highly elevated and dispersed over a large stream segment. Given the historic mining in this watershed, there may be as inactive mine sites that have contributed to the high mercury levels in water and sediments." However, it is not possible at this time to identify the specific sources of and fate of mercury pollution in Jordan Creek.

We have reasonable assurance that waste load allocations will be implemented because two point source dischargers require NPDES permits that will be consistent with the waste load allocations.

Nonpoint Sources

The IDEQ Jordan Creek TMDL (IDEQ 2010) included an Implementation Strategy, which is a phased and iterative approach to mercury reduction that uses ongoing data collection efforts in the area to inform ongoing pollution reduction efforts. This process of adaptive management is appropriate for places like Jordan Creek where there is some uncertainty about the sources and pathways of mercury pollution in the watershed. The first step in the phased implementation is collection of data for source assessment. That data would inform remediation efforts, followed by monitoring and tracking of mercury reductions in water and other media.

EPA expects that IDEQ will execute its Implementation Strategy for Jordan Creek, based on their history of completing implementation plans for other TMDLs approved in Idaho. For example, the Bear River TMDL was approved by EPA in June 2006, and subsequently implementation plans have been completed for eight subbasins within the Bear River watershed. The Cascade Reservoir TMDLs were approved in 1996 and 1999, with an implementation plan completed in 2000. Subsequent monitoring has shown that implementation activities in the Cascade Reservoir watershed have resulted in the statistically significant decrease in phosphorus concentrations. While the pace and success of implementation varies between watersheds for a variety of reasons, Idaho has completed more than seventy watershed scale TMDLs to date, and demonstrated consistent commitment and progress towards completing implementation plans, and follow through with restoration activities.

IDEQ's Implementation Strategy contains mechanisms and procedures for addressing nonpoint sources through its Nonpoint Source Management Plan (NSMP), developed under Section 319 of the Clean Water Act. The NSMP is certified by the Idaho Attorney General that adequate authorities exist to implement the NSMP. Idaho state law also includes provisions to develop Watershed Advisory Groups (WAGs). The Implementation Strategy in the IDEQ TMDL indicates that the WAG will assist with development of the Jordan Creek TMDL Implementation Plan. Idaho's policy is to develop implementation plans within 18 months of the time a TMDL is approved, and to date they have been consistently completing these plans. In general, Idaho uses a voluntary approach to control nonpoint sources. If a voluntary approach does not succeed in abating the pollutant problem, the state may seek injunctive relief for those situations that are determined to be an imminent and substantial danger to public health or environment (IDAPA 58.01.02.350.02(a)). If water quality monitoring indicates water quality standards are not being met, even with the use of BMPs or reasonable practices, the state may request the designated agency to evaluate and/or modify the BMPs to protect beneficial uses. Consequently, the state can exercise enforceable authorities to achieve reductions in nonpoint sources of pollution.

The first task of remediation is source assessment to establish where mercury is leaching into Jordan Creek. The Implementation Strategy encourages federal and state agencies, local government and the stakeholders in the watershed to develop a source assessment for mercury in Jordan Creek . Federal agencies that may have an interest in development of source assessments include EPA, U.S. Army Corp of Engineers, USGS, Bureau of Reclamation (BoR), Natural Resources Conservation Service (NRCS) and the Bureau of Land Management (BLM). State of Idaho agencies that may have an interest in the development of a source assessment include Idaho Department of Lands (IDL); Idaho Department of Water Resources (IDWR); Idaho Department of Health and Welfare (IDHW); IDEQ; and the local health district. Local government entities which may participate in development of source assessments include Owyhee County Commissioners; City of Jordan Valley, Oregon; and Malheur Oregon County Officials.

Consistent with the overall direction of the Implementation Strategy, EPA is currently planning a source assessment to follow up on a preliminary study in the Jordan Creek historic mines area. This assessment is planned to begin in September 2011. The purpose of the study is to evaluate potential source areas, specifically inactive mine sites that may be contributing to mercury loading in the watershed. The scope is approximately 60 samples and 5 or 6 high priority sites. If the State of Idaho, the federal land management agency or the land owner of a contaminated site are not able or willing to initiate a clean-up, EPA has authority through the Comprehensive Environmental, Response, Compensation, and Liability Act (CERCLA) to undertake remediation.

Given the uncertainty of the specific sources of and fate of mercury pollution in Jordan Creek, it is not possible to establish a precise timeframe for meeting the mercury TMDL. IDEQ believes it likely will take decades to achieve. Potential funding sources identified by IDEQ for TMDL implementation include 319 grants funds CERCLA funds, and the state revolving fund.

Point Sources

EPA is responsible for issuing National Pollutant Discharge and Elimination System (NPDES) Permits in Idaho. The WLAs in this TMDL will be used to set permit limits for the Kinross Delamar Mine MSGP Stormwater discharge permit and Groundwater Remediation discharge permit. Kinross Delamar Mine is a former mine site which is now closed. Both discharge permits are needed for reclamation activities at the mine site, which reduce metals inputs, including mercury, to the watershed. Data voluntarily collected by the permit holder indicates that the stormwater effluent from the Kinross Delamar Mine has reduced mercury concentrations and is not adversely affecting water quality in Jordan Creek or tributaries of Jordan Creek into which there are stormwater discharges. The WLA for this source is calculated based on achieving the aquatic life criteria for mercury at the end of pipe, so the discharge effluent itself will meet the water quality standards.

The current Groundwater Remediation discharge permit mercury effluent limits for Kinross Delamar Mine are equivalent to the WLAs set in this TMDL. Data collected in Louse Creek, the receiving water for the discharge, shows that it is below the mercury criteria and has capacity for this discharge (KDMC, 2010). The WLA for this discharge was calculated based on achieving the aquatic life criteria at the edge of a mixing zone. By the time any the effluent from the groundwater remediation discharge reaches Jordan Creek, it will be diluted far below the aquatic life criteria value.

These point source discharges contribute less than one percent of the total mercury loading to Jordan Creek. The allocations for these permits are at the technological limits for removal of mercury from these discharges. If these permits were eliminated it is anticipated that there would be an increase in loading of mercury to the stream because of the loss of best management practices and reduction activities of the mine reclamation action. Eliminating the point source discharges would not lead to achievement of the water quality standards.

Conclusion

Under this TMDL the combined nonpoint source LA and point source WLA do not exceed the water quality standard-based loading capacity, and EPA is confident that the State's plan to reduce nonpoint sources of pollution in the watershed provides assurance that load allocations will eventually be achieved. Idaho's policy is to develop implementation plans within 18 months of the time a TMDL is approved, and to date they have been consistently completing these plans..Appendix A. Information from Kinross Delamar Groundwater Remediation Permit Application.

Table A-1. Projected Effluent Flow Compared to the Design Discharge Rate and Receiving Water Flows.

Date	Peak Effluent Flow[1] (cfs)	Average Effluent Flow[1] (cfs)	Design Effluent Discharge Rate[2] (cfs)	Louse Creek Flow[3] (cfs)	25% Louse Creek Flow (cfs)
January	0.05	0.04	0.12	2.60	0.65
February	0.10	0.09	0.27	4.44	1.11
March	0.29	0.24	0.27	6.41	1.60
April	0.43	0.33	1.30	22.30	5.58
May	0.38	0.28	0.90	15.14	3.78
June	0.17	0.11	0.12	3.45	0.86
July	0.09	0.06	0.09	1.46	0.37
August	0.04	0.03	0.04	0.82	0.21
September	0.03	0.02	0.04	0.67	0.17
October	0.03	0.03	0.04	0.70	0.18
November	0.03	0.03	0.12	2.17	0.54
December	0.03	0.03	0.12	2.05	0.51
Total (Mgal/year)		25.3	67.2		

From KDMC (2010)

1. Effluent flow rates were calculated from 27 months of effluent pumping rates and 5 months of weir measurements.
2. The design effluent discharge rate represents the stream capacity based on a 5.1 dilution factor.
3. Louse Creek flow estimates for the proposed Sullivan Gulch Outfall 001 location were estimated by adjusting the flow data collected at the Cabin Gulch gauging station located approximately 0.8 miles downstream. The flow data for the Cabin Gulch location was reduced by 13% to reflect the reduced drainage area contributing to the Sullivan Gulch location.

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